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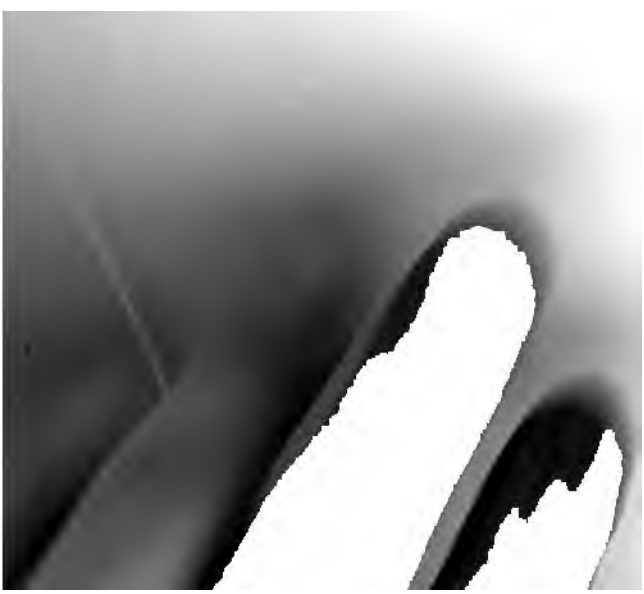

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THE PRACTICE OF DENTISTRY

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A PRACTICAL TREATISE UPON THE GENERAL PRACTICE OF DENTISTRY, OPERATIVE AND PROSTHETIC, EXCLUSIVE OF ORTHODONTIC PRACTICE

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WITH THREE HUNDRED AND FIFTY ILLUSTRATIONS

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PREFACE

The authors and publishers firmly believe that a work purporting to treat of the general practice of dentistry—exclusive of orthodontic practice—constitutes at the present time a distinctive need of the general dental practitioner. The present work has been designed to meet this need. The subject matter has been treated to meet the practical requirements of the active practitioner, who in many instances fails to acquaint himself with the most advanced developments in his profession because he is disinclined to wade through the multitudinous detail to be found in textbooks prepared for the education of beginners in dentistry, and which is generally regarded as being quite necessary for the proper elucidation of the text to be impressed upon the dental novitiate, but which detailed method of treatment is neither necessary nor impressive for the experienced practitioner.

The authors also believe that the present work is characterized by a degree of homogeneity not to be found in works completed under separate authorship, and the opportunity of noting the conduct of a dental practice, the various departments of which have been brought into harmonious relation with each other, we think will be acceptably received by the reader.

As an example of contradictory recommendations that are likely to appear in a work published under separate authorship, and which no doubt are quite unavoidable, may be cited the condemnatory ground assumed by one author in a well-known textbook in regard to use of cocain for the extirpation of the dental pulp for fear that it may reach the pericemental tissue, and being a protoplasmic poison a destructive irritation of this tissue is likely to ensue, while in other chapters of the same work different authors highly laud the use of cocain, not only

for the purpose of extirpating the pulp, but for other uses directly or indirectly involving the pericementum. Such flagrant contradictions are frequently encountered in publications covering the practice of either dentistry or medicine, designed under separate authorship, and which are not likely to be found in those designed under single authorship.

The authors have spared no effort to bring the present publication up to the accepted advanced standards of dental practice, and to present these as concisely as in their judgment appeared prudent. Their appreciation is here gratefully acknowledged for the results obtained by many investigators in the field of dental endeavor, and which have been of material assistance in making possible this publication; to the various publishing houses for the use of illustrative cuts; to the publishers for their generous treatment and indulgence throughout the preparation of this work; and to Dr. W. J. Robinson of Philadelphia, who rendered valuable aid in the construction of many appliances appearing in the section upon bridgework.

THE AUTHORS.

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OPERATIVE DENTISTRY

CHAPTER I

DENTITION: THE FACTORS AND PERIODS OF ERUPTION OF DECIDUOUS TEETH

Definition and Theories.—Dentition, or the eruption of teeth, may be defined as a series of vital phenomena having for their ultimate aim the physiological placement of the teeth. In order to better comprehend the process of eruption, it is necessary to fully comprehend tooth development and the state, at this time, of the surrounding tissues. And if our knowledge is to be made subservient to the pathological as well as the therapeutic aspects of dentition, we must, furthermore, have a complete understanding of the causal factors which induce the formed teeth to seek their positions in the dental arch. To realize that this is not so simple a process as is generally regarded, we have but to consider the many theories that have been offered, from time to time, in explanation of the phenomena.

One of the oldest of theories offered to account for the passage of a tooth from its bony crypt to its proper alveolar position was that of the elongation of its root or roots. As the root increased in length owing to dentinal deposits, so the crown was forced to move in a direction toward and finally pierce the overlying gum tissue. This theory is still in vogue with many dentists, in spite of its well-known inability to satisfactorily explain certain conditions. For instance, it is urged that if root elongation is the active factor of eruption, how

does it account for those instances of eruption where the crown travels a greater distance than the length of the root? Again, how does it explain those cases where teeth with fully formed roots remain unerupted, and, furthermore, where teeth with fully formed roots remain unerupted and at a later period erupt? These are serious and well-sustained objections which the votaries of the root elongation theory have not as yet cleared.

Dr. Peirce in the "American System of Dentistry," writing in explanation of this last objection, says: "There is a mechanical force, however, acting on all such teeth tending to bring them to the surface, the same as on an unantagonized tooth, inducing its elongation or protrusion from the socket. The repeated closing of the jaws must exert to a large extent this mechanical force, just as the bung in a barrel is elevated by a blow being struck upon the stave or either side of it."

Dr. Tomes contends that fully formed teeth that subsequently erupt do so because of the contraction of the lower portion of the socket, from which the tooth emerges by the deposition of bone.

Constant,[1] who has done more to clear the question of eruption of the teeth than any one else, says: "It appears to me that the chief objection to the root elongation and bone formation theories is a physiological one. It is extremely difficult to conceive such a process as dentin formation exercising independent mechanical force! But, granting that it may be so, upon what structure is that force exercised? In other words, to put the matter clearly and concisely if somewhat vulgarly, what does the root shove against? Since the forming root is never in actual contact with its bony surroundings, it must necessarily be against the vascular material in which it is em-

[1] *International Dental Journal,* 1903.

bedded. Now, the tissue appears post mortem of far too jellylike a consistence to oppose any effective resistance by virtue of its own structure, and yet such resistance there must be or the tissue would be obliterated. Whence, then, are its resisting properties derived? Necessarily from the *blood pressure.*"

This force, as an active agent in the eruption of teeth, had been entirely overlooked until Constant directed the attention of the profession to it, and it not only appears satisfactory in accounting for the elevation of teeth, as Fig. 1 shows, but it is quite able to better account for

A B C D

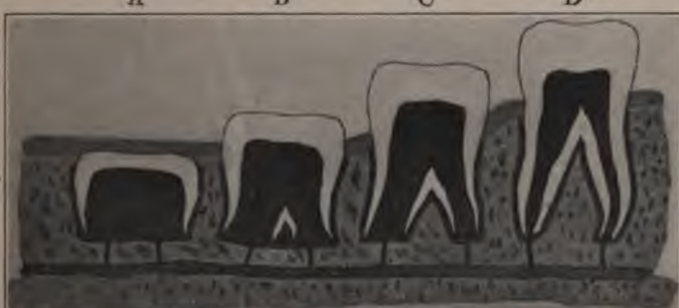

FIG. 1.—SECTION THROUGH A LOWER MOLAR TOOTH. (Constant.)

those cases of eruption either unaccounted for or else very poorly accounted for by any other theory extant. Fig. 1 is a diagrammatic illustration by Constant. He says:

"A, B, C, D represent a section through a lower molar tooth and its crypt at various stages of development. In A it is obvious that the pulp forms a fleshy column of vascular tissue upon which the crown really rests. The pulp itself is injected by the force of the blood pressure entering almost directly from A, an artery of considerable size. Under the calcifying margins of the crown is the pad of tissue that forms the junction of the sac and pulp, and between the crown and the walls of the crypt

is the vascular tooth sac, which is injected from the same source as the pulp. Above the crown are the oral mucous membrane and submucous tissue. Now, it is obvious that the blood pressure exerted in the pulp tissue acts upon the crown at a considerable mechanical advantage in comparison with the pressure in the tissues overlying the crown. Indeed, it is only necessary to glance at the diagram to understand how it is that some teeth travel so quickly to their destined position when once their crowns have emerged from the gums. In fact, with regard to this point, it is a marvel that dentists, who have many opportunities of observing the rapidity with which teeth sometimes move during eruption, should ever have been induced to regard the comparatively slow process of dentification as the active agent in the matter."

Does not the theory of blood pressure obviate the several objections, one or all of which may be sustained against all other theories? Under it no limit is set to the distance a tooth may travel except that imposed by the antagonizing teeth, and, as the diagram so clearly indicates, that, as the tooth moves progressively through the gum, the blood pressure necessarily is diminished owing to the contraction of the pulpal mass. One other fact may be cited here before proceeding with the other test, and that is that it better explains the elongation of unopposed teeth than Dr. Peirce's explanation. The other test to which reference has been made is that teeth may erupt after root formation is complete. This phenomenon can be explained more satisfactorily by this theory than any other. Under the blood pressure theory no difficulty exists to account for the space necessary for the developing roots. As Constant explains: "The blood pressure acting as it does equally in all directions makes room for the developing root in the direction of least

resistance. Normally, this is in the direction of the advancing crown, but occasionally it is elsewhere."

Periods of Eruption.—Most writers name the *seventh month* as the time for the appearance of the first deciduous tooth, the inferior central incisor. Dr. J. Foster Flagg names from five to seven months as the period of eruption of the inferior central incisor. From a record of nearly one hundred cases, in private practice, the average time of eruption of the inferior incisor is somewhat later than the *ninth month.* In several instances the first tooth did not appear until after the *fourteenth month.* In one instance of this excessively delayed eruption the child was mother nursed until the eighth month, and presented every other indication of normality. That abnormal nutritive conditions appear to be related to delayed dentition is a matter in which pediatrists generally agree. So, too, may it be observed that children with syphilitic taint usually erupt their teeth at an earlier period. The following table is the summary of many hundred cases observed by Dr. J. Foster Flagg:

Central Incisors.........	Lower,	5- 7	months
	Upper,	7- 8	"
Lateral Incisors.........	Lower,	8- 9	"
	Upper,	9-10	"
First Molars............	Lower,	11-12	"
	Upper,	13-14	"
Cuspids.................	Lower,	17-18	"
	Upper,	19-20	"
Second Molars..........		23-20	"

It is to be observed that the time of eruption of the central incisor may not be a matter of general concurrence among practitioners, but the time of eruption of

the cuspids and second molars is not at any wide variance.

It has been maintained, notably by Flagg, that the child's second summer is most fraught with danger in consequence of dentition. At this time it is erupting either the cuspids or second molars, and, as these teeth usually erupt in fours, the effects upon the child are likely to be more severe. However, under proper surveillance the critical period, as a rule, is passed in safety.

With an understanding of the forces at work in directing a tooth into its proper position, together with a knowledge of the periods in which the teeth are likely to appear, especially those most liable to give rise to pathological complications, we are better prepared to intelligently consider those instances where resorption of the roof of the bony crypt and overlying gum tissue is retarded, in consequence of which a backward pressure is exerted upon the pulp, which, owing to the close relationship existing between the *fifth* and *seventh, ninth* and *tenth* cranial nerves, may give rise to a series of pathological sequences, at times sufficiently severe to terminate in death of the child.

For our study dentition may be divided into *Physiological*, or normal, and *Pathological*, or abnormal.

Physiological Dentition.—Where the processes of resorption and tooth advance are about equal the tooth assumes its position in the arch with so slight a disturbance of normal conditions that we may consider the process of dentition to be within physiological bounds. Under these conditions teeth not infrequently erupt with no sufficiently marked symptom to invite attention. An increased flow of saliva, reflexly induced, may exist. The child may also show a disposition to have its gums rubbed for some time previous to the appearance of the crown

of the tooth, owing to their mild hyperemic state; otherwise no evidence can be found of the eruptive period. At times the child is irritable, refuses nourishment, gives evidence of pain when pressure is made upon the gum, its sleep may be disturbed, the gum color may be heightened, and the tissue slightly swollen; these symptoms may appear for a few days and then gradually subside and finally disappear, and with their disappearance the crown of the tooth may be seen to emerge through the gum tissue. These cases, unquestionably, are more severe than those previously noted, but nevertheless they may pass for cases of *physiological dentition.*

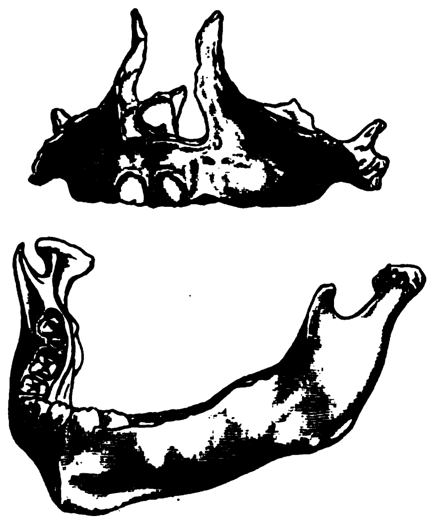

FIG. 2.—RESORPTION OF WALL OF CRYPT PRIOR TO ERUPTION. (Tomes.)

Pathological Dentition.—When the symptoms noted above appear to increase in severity and, with their increase, we also find evidence of alimentary disturbances, eruptions upon the skin, coughing, and, from its continued refusal to take a normal amount of nourishment and the persistence of the alimentary disturbances, the child loses weight, we may conclude that the physiological aspects of dentition have been passed. Its pathological manifestations are clearly before us, and sufficiently impressive to clearly indicate the exercise of such therapeutic measures as will promptly eliminate all danger. It

is to be noted that cases occur in which dentition appears to be progressing most favorably, *i. e.*, without pathological complications, that without any warning assume a pathological aspect most dangerous to the life of the child. A case recently came under the authors' observation in which a child 18 months old appeared entirely well, without the slightest evidence of pathological dentition, but, after its evening meal, was found in an eclamptic state, from which it was relieved only after prolonged efforts. It is quite necessary to be watchful, for the apparently simple cases may possibly assume serious aspects without timely warning.

INTESTINAL DISTURBANCES.—Intestinal disturbances appear to be almost universally concomitant of pathological dentition. The irritation of the fifth nerve, through the pulp, may result in a reflex irritation of the entire alimentary canal through the close association of the fifth and the pneumogastric—and, as Musser[1] has pointed out, the *Bacillus coli communis* and *Bacterium lactis aeriformis* may exist harmless in the intestinal canal under normal conditions, but may develop during periods of intestinal irritation. Then, again, products of incomplete digestion, due to its impairment, may set up a train of alimentary symptoms such as may be noted at this time, and, furthermore, the state of the child may be complicated by a condition of autointoxication due to the absorption of toxic substances from the intestinal tract rendered especially prone to putrefactive changes at this time.

NERVOUS DISTURBANCES.—In the severer forms of pathological dentition we may find further complications through a central nervous irritation. At first spasmodic muscular contractions may be noted affecting the eyelid

[1] "Medical Diagnosis."

and lips; the fingers may be drawn toward the palm of the hand; or the toes toward the sole of the foot; the child is listless and aroused with difficulty; from this listlessness it may pass into a state of unconsciousness, or it may give a sharp cry and with the eye turned upward unmistakably indicate the eclampsia. Some writers [1] regard the convulsive attacks as being indicative of a neurotic family type. However, the factors of dentition are entirely competent to account for such attacks, and although neurotic conditions may predispose the child to convulsive manifestations, these may appear in the absence of inherited predisposition.

THERAPEUTICS.—It may be stated with a degree of assurance born of conviction that in many cases the severer manifestations of pathological dentition might be avoided. Unfortunately tradition too frequently makes us slaves of belief. Too many mothers are the victims of the belief that it is necessary for the child to pass through certain ailments before its teeth appear. From the sixth month of the infant's life until it has passed beyond dentition whatever departure from health it may disclose is at once expressed in terms of *teething*. This induces a degree of *negligence*, in many instances, which is the true cause of the child's sickness. Therefore, from the time of birth the *hygiene* of the child should be the study of those having its care under command. The importance of this cannot be too strongly emphasized; and its disregard, in many instances, is responsible for the severer pathological manifestations during the teething period. This applies with especial force to the care exercised in regard to the cleanliness of nursing bottles, teething rings, etc.

In many instances, however, the need for therapeutic

[1] Burchard, "Pathology and Therapeutics."

aid will exist even though a most thorough hygienic régime may have been practiced. The indications for therapeutic aid may be arranged under two heads: *The moderately severe* and *the dangerously severe.*

With the *moderately severe* we may associate all those symptoms which have passed the physiological aspects of dentition, but do not threaten the life of the child. These generally include an inflamed gum with its possible septic sequelæ and the gastrointestinal disturbances, at times exceedingly difficult to control. For the inflamed gum ice held in a sterilized gauze affords relief. It also allays the febrile condition of the child. Should the contact of the ice, and the tendency of the child to bite upon it, prove too painful, the gauze may be soaked in cold water and applied to the inflamed gum. A drop or two of paregoric rubbed upon the gum will be found very valuable, and, although some objection may be urged against its use, in the authors' experience it has proved decidedly helpful. Solutions of boric acid may be frequently applied, the attendant wrapping a piece of antiseptic gauze about the finger, dipping this into the solution, and carrying it into the mouth. Drinking water should be freely supplied to the child. A teaspoonful of sweet spirits of niter may be added to a glass of water, and of this solution a teaspoonful may be given as frequently as desired. Antiseptic precautions must be rigidly enforced. The use of solutions of boric acid has been noted. Any of the modern antiseptic preparations may be substituted. They are non-irritating and non-poisonous. Not only is it important to enforce antiseptic precautions to prevent serious local effects, but, recognizing the likelihood of a gastrointestinal irritation as the concomitant of pathological dentition, the presence of septic matter in the oral cavity might

prove to be a factor leading to grave complications.

The condition of the gastrointestinal tract should receive close attention. At times it may be difficult to diagnose between an intestinal irritation and hyperemia reflexly induced and one due to the irritating products of incorrect feeding. If evidence of pathological dentition exists in the mouth, the gastrointestinal condition may safely be considered as being due to it, providing that no previous history of intestinal derangement can be made out. The character of the intestinal discharges also may aid in formulating a diagnosis. Watery spinach-like discharges generally indicate a catarrhal intestinal condition associated with incorrect feeding. But the possibility of the gastrointestinal condition, even though strongly indicative of its infective character, being primarily due to pathological dentition, necessitates, at all times, the closest deliberation in making a diagnosis. In either case the use of calomel in 1-10 gr. doses until 1 gr. is taken, followed by citrate of magnesia i℥, or milk of magnesia in iʒ dose, is indicated, or castor oil in iiʒ dose may be given. This has a soothing effect upon the entire intestinal tract. After thorough bowel evacuation salol in 1 gr. doses every 3 hours is of value. In those cases where the desire for food remains below normal, after the intestinal cleansing, Tr. nux vomica in 1-2 drop doses 3 times a day will prove beneficial.

With the second division of symptoms of pathological dentition, designated the *dangerously severe,* we may associate those pointing to central nervous irritation: spasmodic muscular contractions of the eyelid and lips, drawing the fingers toward the palm of the hand, or the toes toward the sole of the foot, or the sharp cry that may precede the convulsive attack. The existence of any of these signs indicates the need for prompt thera-

peutic interference. The large intestines should be evacuated by means of an enema of 1 pint of water containing a tablespoonful of glycerin, after which a normal salt solution, or ii℥ of milk of asafetida, may be injected. For the eclampsia the child is to be immersed to the waist line in warm water and cold applications are to be made to the head. With the return of consciousness the treatment previously noted may be followed; or 2 or 3 grs. of chlorate hydrate may be given in a rectal injection. Children[1] bear this drug very well and its sedative action on the nerve centers is of value following the convulsion.

The most effective remedy to guard against the appearance of the severer nervous manifestations is to be found in *gum lancing.* Many an impending attack of eclampsia has been averted by the prompt use of the knife. Medical writers do not give concurrence to the view that pathological dentition may directly lead to convulsions through reflex nervous irritation, but, nevertheless, it is the conclusion of most dental writers, especially those with considerable clinical experience. Probably the strongest corroborative evidence to this conclusion is found in the many instances in which gum lancing, the only remedy employed in a threatened eclamptic attack, successfully averted the danger. Attention has been directed to the predisposition of the intestinal tract, during the teething period, to fermentative changes, due both to reflex nervous irritation and to the presence of irritating products of incomplete digestion and bacteria. This may lead to a toxemia resulting in central nervous involvement. Furthermore, an affirmative state of a tainted neurotic inheritance may also predispose the child to easily excited convulsive paroxysms; but that the

[1] Tyson, "Practice of Medicine."

pressure of unformed root ends upon the pulp tissue resulting from the resistance of the overlying tissues of the crown is competent to account for the severest and most frequent attacks of so-called teething convulsions through irritation of the trigeminus and consequent reflex disturbances of nervous centers is fully in accord with a physiological knowledge of the factors involved and with the conclusion of those who have had almost unlimited clinical experience in the observation and treatment of pathological dentition.

Gum Lancing.—The operation consists of making, at first, linear incisions (Fig. 3) at such locations as will remove the mechanical resistance which the gum tissue offers to the advancing tooth, and thus relieve the backward pressure upon the pulp. It is almost impossible to properly perform this operation without the assistance of some one to properly secure the child and prevent any sudden movement, otherwise the surrounding tissues are in danger of injury. Prof. Garretson favored placing the head of the child between the knees and an assistant sitting opposite holding the body and arms of the child in a way to make any sudden movement impossible. The fingers of the left hand are free to guard the gum tissue, and the operator is in excellent control for either the superior or inferior arch. Prior to making the incision the mouth is swabbed with a 10% solution of dioxogen, phenol sodique, or listerine solution. The blade of the knife may be wrapped in gauze, leaving the point alone exposed. This

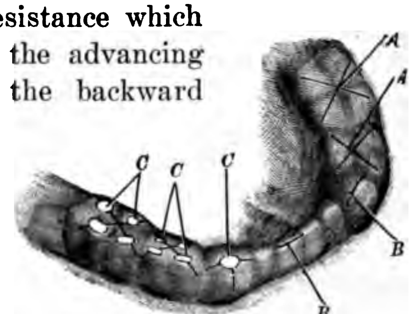

FIG. 3.—GUM LANCING. (Burchard.)

lessens any danger of injury to the surrounding tissue that may arise. For the superior incisors the incision is made on a line with the arch, slightly labially. For the inferior incisors the incision is made on a line with the arch, to the lingual side. This favors the proper occlusion of the teeth. For the cuspids the incision, at first, is similar to that made for the incisors—after the point of the cusp appears the gum is incised at the four points shown in the illustration. For the molars an X incision is made, and in severe cases a ring of gum tissue may be removed.

The bleeding which follows the operation is, as a rule, insignificant and rarely requires the use of a remedy for its arrestation. If, however, the bleeding should be prolonged, a piece of ice held in gauze, or the use of a weak solution of adrenalin, or any other styptic applied to the wound, speedily controls the hemorrhage. In very severe instances one drop of Tr. erigeron canad. every five minutes is considered an excellent internal remedy.

Infantile Scurvy.—The ecchymoses of the gum, characteristic of infants who have been improperly nourished, may lead to an error in diagnosis. The gum hemorrhage, the weakness and listlessness of the child, its alimentary disturbance, may be confounded with *pathological dentition*. A case under the authors' recent observation fully confirmed the possibility of an error being made in distinguishing between the two conditions. An infant of eight months gave evidence of gastrointestinal disturbances in attacks of vomiting and diarrhea. Up to the time of these attacks it appeared to be in satisfactory physical condition. Preceding the evidence of gastrointestinal disturbance the appearance of blood in the mouth that apparently had its origin in a swollen gum was noted. The condition of the mouth rapidly grew

worse, until the gum presented a deep purplish color, with considerable swelling, and the slightest pressure upon it resulted in hemorrhage. Two physicians diagnosed the condition as one of pathological dentition, and not until the critical condition of the child led to a consultation with a specialist was the correct diagnosis made of *infantile scurvy.* With a change in the food and the use of orange juice, speedy recovery followed.

CHAPTER II

DENTITION OF THE PERMANENT TEETH

The deciduous teeth having erupted, the child enjoys a period of about three or four years before any evidence of dentition again appears. When this occurs, it is in a position posterior to the second deciduous molar. Fig. 4

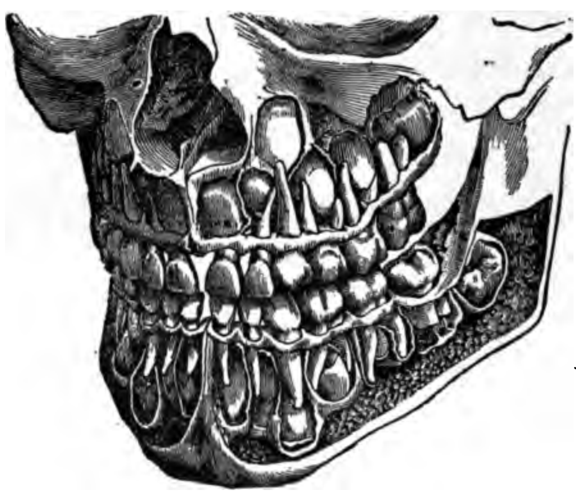

FIG. 4.—ERUPTION OF FIRST PERMANENT MOLAR. (Burchard.)

shows the first permanent molars elevated with their normal positions; the roots are still incomplete. The eruption of the permanent teeth is to be considered as being due to influences similar to those of the deciduous teeth. At the time the first permanent molar is erupting all of the permanent teeth are in the active process of formation; in fact, we may say that, with the

giving off of the bud for the third molar, which occurs about the third year after birth, all of the permanent teeth are in the formative state.

They erupt in the following order, with some deviation as to the time:

First Molars	6- 7	years
Central Incisors	7- 8	"
Lateral Incisors	8- 9	"
First Bicuspids	9-10	"
Second Bicuspids	10-11	"
Cuspids	12-13	"
Second Molars	12-14	"
Third Molars	16-45	"

At the time that the first permanent molars erupt the roots of the deciduous teeth are in the process of decalci-

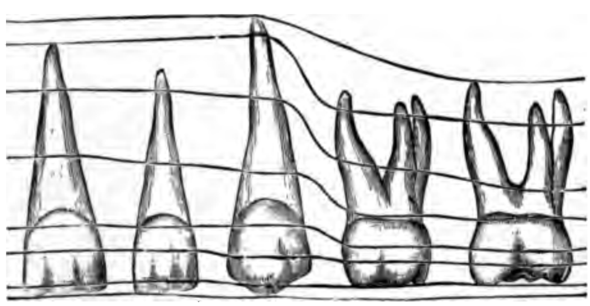

FIG. 5.—CALCIFICATION OF THE DECIDUOUS TEETH. (Peirce.)

fication. Figs. 5 and 6 can be compared as to both calcification and decalcification. At the age of seven the roots of the central incisors are almost completely resorbed; the laterals about two-thirds their length, and the first molars the apical ends. The cuspids and second molars have not as yet been affected.

Resorption.—Resorption of the deciduous roots is

accomplished by what is known as the *resorbent organ*, a name given by Tomes to an area of giant cells called odontoclasts (Fig. 7) occupying the space between the

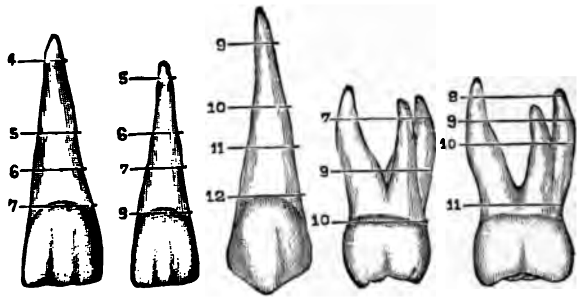

FIG. 6.—DECALCIFICATION OF THE DECIDUOUS TEETH. The numbers indicate years. (Peirce.)

advancing crown and the root of the deciduous tooth. The process, according to most recent investigations, is a form of *phagocytosis*. The giant cells of the resorbent organ, which appear no doubt through pressure stimulation, secrete a substance, very likely an acid, which is capable of effecting bone solution. As the root of the deciduous tooth is gradually dissolved the pulp becomes part of the resorbent organ and may retain its vitality until the entire root has been resorbed. Where the pulp, through the action of caries or an injury, loses its vitality and septic processes supervene, the resultant products are very apt to disturb the function of the resorbent organ. In such instances root resorption is incomplete and the permanent tooth may be deflected from its regular course. If the septic condition is corrected, root resorption may be resumed.

FIG. 7.—THE RESORBENT ORGAN SHOWING MULTINUCLEATED CELLS. (Tomes.)

Pathological Complications and Their Treatment.—The permanent teeth, as a rule, attain their proper positions in the arch without any pathological complications. The general exception to this rule is the third molar. The inferior second molar may, through lack of space, at times give indications of a slight abnormal eruption, but at no time is it likely to assume serious aspects. If the gum is incised or a block of gum tissue removed, most generally without the assistance of any therapeutic measure, the tooth attains its place in the arch. With the third molars, especially the inferiors, the situation frequently demands aid, and in some instances very aggressive measures are necessary to insure a return to normal conditions. The superior third molar sometimes erupts buccally, due to a dense maxillary tuberosity, the tooth erupting along a path of lessened resistance. This of itself, however, does not establish the pathological association. It is only after the crown is fully erupted that, in its abnormal position, it acts in a favorable manner for food and bacterial retention, which leads to infective processes. The authors have had a number of cases where patients suffered from an extension of the infective process, where more than the usual hygienic measures were practiced, reaching backward to the tonsillar region, and after several recurring attacks extraction was decided upon, after which the pharyngeal area remained normal. Then, again, the cusps of the tooth may lacerate the buccal mucous membrane, owing to the abnormal position of the tooth, and this may be so severely inflictive as to necessitate their removal as a preliminary expedient of relief, to be followed by extraction, if the former measure does not prove effective.

The inferior third molar is of far greater importance in its pathological considerations. In almost all cases

of an erupting lower third molar, with the seven teeth in anterior position, some degree of disorder will be noted. From a mild eruption with its corresponding mild degree of annoyance, indicated by pains referable to the angle of the mandible, pains coursing toward the ear and down the neck, interference with the normal opening of the mouth, due to stiffness of the muscles of mastication the gum overlying the region of the tooth may be hyperemic. These symptoms may continue for several weeks, or months, before the cusps of the tooth finally appear. The diagnosis becomes quite evident, even before the cusps of the tooth appear, in view of the continued neuralgia, its location, greater or less immobility of the mandible, and where inquiry reveals a negative answer as to the prior appearance of the tooth.

In the severer forms of pathological involvement the symptoms at first are similar to those noted above, but quickly become very severe. The patient is unable to take anything but liquid nourishment, and in some cases even this becomes impossible because of the complete trismus. The gum becomes inflamed and, owing to the presence of pyogenic bacteria, an infective inflammation with its suppurative sequence occurs. The inability to introduce antiseptics allows of a free, and therefore very severe, septic process, and unless aggressive therapeutic measures are adopted without delay, or where the patient's resistive qualities are below normal, septicemia and death may follow. These dangerous terminations may quickly follow the milder symptoms; therefore it is not prudent to temporize with the condition. If, after anointing the region about the angle of the mandible with an ointment consisting of equal parts Tr. aconite, Spts. chloroform and Tr. opium, combined with a massage of ten to fifteen minutes, or after the use of either

of the ointments so favorably recommended by Dr. Flagg,

℞ Aconita gr. j.
Cerat Simp. ℥j.
M.

or ℞ Veratria grs. xx.
Cerat Simp. ℥j.
M. (Great care must be observed in the use of the above ointments that these powerful poisons do not reach mucous surfaces.)

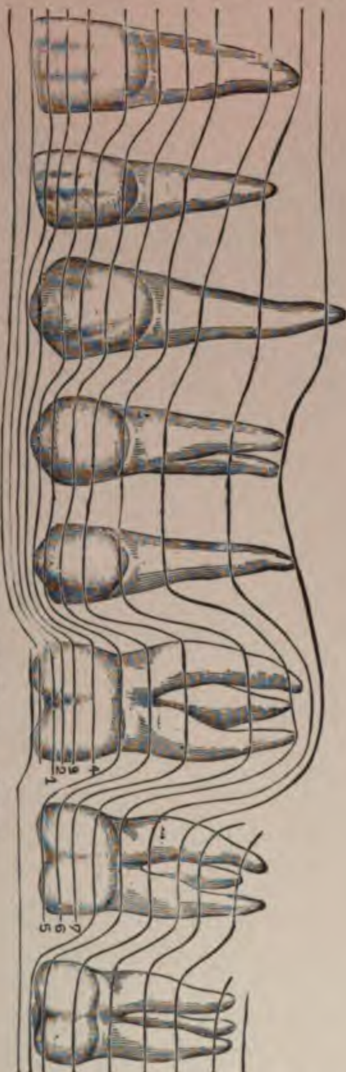

Fig. 8.—Calcification of the Permanent Teeth. (Peirce.)

the trismus persists, the jaws are to be forcibly opened even if recourse must be had to ether as an anesthetic and a jaw separator. Hydrogen dioxid full strength may be used as a disinfectant, and a ring of gum tissue is to be removed. If this is not followed by a speedy amelioration of the symptoms the second molar should be extracted, or the third molar is to be removed. A radiograph reveals the exact location of the tooth, and by raising the gum tissue and removing the process by means of the engine and bur, the tooth may be lifted from its socket. Extraction of the second molar usually means the loss of two teeth, as the third molar dips forward, throwing its anterior cusps

out of occlusion. However, this may be avoided by inserting an artificial tooth after the third molar is in position.

Fig. 8 shows at what age calcification of the permanent set is completed. This is of value in making arsenical applications for pulp devitalization, especially for the first permanent molar. An earlier period than the tenth year may allow of the passage of the arsenic through the unformed root end.

CHAPTER III

DENTAL CARIES: HISTORY AND ETIOLOGY

The history of dental caries represents a succession of attempts to solve the problem of cavity formation in teeth, each attempt serving as a stimulus and guiding light for subsequent investigations. Sufficient time has now elapsed since Dr. Miller's memorable work to clearly delineate the decisive steps in this progressive evolution. A succinct recital of the work cannot be without interest even to the informed practitioner.

In 1835 Robertson, an English writer, attacked the inflammatory theory then in vogue and contended that decay of the teeth must be due to an acid; that this acid was formed by the decomposition of food retained in pits and fissures, and that it acted chemically, removing the calcium salts of which the tooth is composed. This appears to be a decisive step in the attempt to solve the problem of tooth decay. Most writers before this period, notably Hunter and Fox, considered the process similar to caries of bone, and regarded it as occurring in the dentin and penetrating outwardly. Dr. Black[1] records that as early as 1530 an anonymous German writer argued that decay of the teeth was due to an acid. Most likely this opinion was but a shrewd guess. John Tomes, of England, a tireless and most painstaking investigator, rendered valuable aid toward the solution by describing

[1] "Operative Dentistry."

the histological formation of the structures of the teeth, thereby showing that the dentin cannot be the seat of blood circulation, and effectively disproving the inflammatory theory still prominent in his day. Dr. Magitot, of France, also a tireless investigator, seriously occupied himself with the problem of caries, and published in 1878 an extensive series of investigations committing him to the view that decay of the teeth was due to an acid formed in the mouth or introduced with food.

Before this period, however, views had been advanced that microörganisms might be a causative factor of decay. In 1867 Leber and Rottenstein wrote concerning the presence of fission fungi in carious dentin. In 1881 Miles and Underwood determined that the dentinal tubes contained living organisms, by adopting the staining methods introduced by Dr. Koch, but their researches were beset with insufficient bacteriological knowledge, which prevented them from obtaining the biological knowledge of bacteria necessary for the determination of special forms of fermentation. It is not difficult, nor unreasonable, to presume that these investigators very likely would have reached the solution of the problem of dental caries had they been fortunate enough to have had the aid of Dr. Koch's laboratory. This in no way lessens the glory of Miller's work, to whom we are indebted for the solution of the process of decay of the dentin. Dr. Miller conclusively demonstrated that decay of the teeth was due to lactic acid fermentation; that the acid so formed removed the lime salts of the enamel and dentin, and that subsequently in the dentin, where 28% of organic matter is found and which the lactic acid cannot destroy, this organic matter is decomposed by bacterial ferments. In the enamel but a trace of organic matter is found, insuffi-

cient for the retention of the enamel form, after the loss of its lime salts by the action of the acid; therefore, when the enamel is attacked by lactic acid, it is but a matter of time when it is completely destroyed. In decay of the dentin, after the acid has removed the constituent calcium salts, its form is still retained by virtue of the organic matrix. A cavity is not formed until the remaining organic matrix is destroyed through the action of saprophytic bacteria. The cavity is formed always in the same direction, from without inward. This is Dr. Miller's work, and, as has been noted, although several writers from as early as the sixteenth century intimated that decay of the teeth was due to an acid, not one prior to Miller succeeded in demonstrating the nature of the acid or the manner in which it is formed.

Dr. Miller produced a pure culture of the bacteria taken from carious dentin. Sections of a sound tooth were placed in tubes to which was added a 2% aqueous extract of beef; in one a small amount of cane sugar was added. These tubes were sterilized and subsequently infected with the pure culture of the germs obtained from carious dentin. The tube containing the sugar solution promptly revealed an acid reaction; in two weeks complete decalcification occurred, and in three weeks cavities were formed in the sections, showing the same characteristics as those found in living teeth. In the tubes containing no sugar neither acid nor decalcification could be detected.

The nature of the acid was detected in the following manner: After its formation through fermentation in solutions of starch and saliva, it was collected and tested with methyl violet; not showing the blue and green test, it was concluded that the acid must be one belonging to the organic group. To the prepared concentrate, ether

was added to effect its solution; the solution was filtered and further concentrated. To this was added zinc oxid and the mixture allowed to boil. After crystallization had taken place the microscope revealed the character of the crystals to be zinc lactate.

In so far, then, as has been stated, viz., the nature of the acid and the manner of its formation, the phenomena of caries of the teeth seem to be incontrovertibly established. There are, however, several features of dental caries which still remain unknown, leaving the subject more or less unsolved. For example, the inception of caries is due, as has been noted, to the growth of microorganisms in contact with the enamel, and the change which they are capable of effecting in carbohydrates, resulting in the formation of lactic acid. In order that the lactic acid may be effective in removing the calcium salts of the enamel, protection must be afforded this acid to prevent its being washed away by the saliva. This is a condition emphatically insisted upon by both Dr. Black and Dr. Williams, two of our ablest investigators in caries of the enamel. Without this protection to the acid decay of the enamel cannot occur. This protective condition is brought about through the formation of the *bacterial plaque,* the *microbic plaque,* or the *gelatinous plaque,* the various terms applied to this protective covering. This protection may also be brought about, as Dr. Black states, through the protection of crowns, bands, or any fixture which may be adjusted to the teeth and which prevents the washing away of the acid after its formation.

The investigations of Black, conducted in 1886, also disclosed the power of certain organisms to gelatinize the media upon which they were cultivated, and later of Goadby, who showed, in his observations of the *Staphy-*

lococcus viscosus, its power of excreting a viscid mucinous substance which might under favorable conditions protect the lactic acid from being washed away. These views appear to indicate that not alone is it necessary to have the germ capable of changing carbohydrates into lactic acid, but acting with this germ must be one capable of forming the plaque through which is realized the protective step absolutely necessary for the localization of the carious process upon smooth enamel surfaces. That this coöperative relationship of different organisms exists in caries has not been shown. In fact, it may well be doubted that the most prevalent of diseases could depend upon its origination, in many instances, to the fortuitous association of different classes of organisms.

The report [1] of the Chairman of the Committee of Scientific Research of the New York State Dental Society states that the bacterial plaque is not composed of gelatin. This committee was formed to investigate the solvent power of sulphocyanate of potassium upon the bacterial plaque. Their findings showed the solvent power of the above salivary constituent upon gelatin, but as this committee also determined that the bacterial plaques *did not consist of gelatin,* the question was quite as unsolved as before. More recently (*Cosmos,* Feb., 1910) this same committee reports the results of its investigations concerning the effect of sulphocyanate of potassium in retarding plaque formation. It found that plaque formation was five to six times more prevalent when grown in media without this salt. Dr. Low, of Buffalo, proceeding a step farther, reports that when the salivary tests reveal the existence of a deficiency of the sulphocyanate salt, and where a condition of susceptibility to

[1] Dr. L. M. Waugh, *Cosmos,* 1908.

caries exists, the internal administration of the sulphocyanate of potassium, in ½ gr. daily doses, changes the condition of the individual, in a large percentage of cases, to one of a notably lessened susceptibility.

These reports are of interest because of their supposedly direct bearing upon the conditions of *immunity* and *susceptibility* to caries. No observant practitioner can fail sooner or later to reach the conclusion that some individuals pass through life presenting a singular *immunity* to caries, while others show an equally singular *susceptibility* to caries. Equally strange are the recurring periods of both immunity and susceptibility to this disease which many manifest. Many of those belonging to the immune division appear to be so almost in the entire absence of hygienic measures, while on the other hand many belonging to the susceptible division appear to be so, irrespective of a conscientious indulgence of hygienic measures.

The investigations of the saliva, which practically had their beginning with the studies of Michaels, of Paris, reported in 1900, undoubtedly appear to connect the question of *immunity* and *susceptibility* to caries with the quantitative presence in the saliva of the sulphocyanate of potassium. When this salt is present in the saliva in certain proportion, almost an unvarying state of immunity is found, and in its absence a corresponding state of susceptibility is found. These observations have been corroborated by subsequent investigations. However, the investigations of the committee previously noted, while confirming the quantitative presence of the sulphocyanate salt in the saliva with the condition of immunity to caries, failed to scientifically establish the relationship in its full meaning.

In the *Cosmos*, December, 1909, Dr. Kirk, commenting

upon existing knowledge of caries with its related plaque formation, offers the following as a simpler and more direct explanation: "It is known that the saliva of caries susceptibles is alkaline or neutral, as a rule; that the saliva is usually viscid or mucinous, because only an alkaline saliva can hold mucin in solution. Again, such a saliva, containing also a fermentable carbohydrate and organisms capable of generating lactic acid, furnishes the conditions necessary to the production of a bacterial plaque; for the smallest addition of lactic acid to such a saliva immediately causes a precipitation of mucin within the sphere of contact of the acid with the mucin, which falls down as a glutinous mass and by condensation upon the surface of the tooth surrounds the mass of lactic-acid-producing germs, agglutinates them and fixes them in adhesive contact with the enamel." In a more recent writing (*Dental Digest*, December, 1910) Dr. Kirk presents a similar explanation as to one mode of plaque formation, and claims to have experimentally produced the bacterial plaque by inoculating with caries fungi a pabulum consisting of glucose and salivary mucin, made alkaline with dibasic sodium phosphate. The acid due to fermentation precipitated the mucin in the form of a plaque.

The view is also expressed that immunity and susceptibility to caries are dependent upon the composition of the saliva, in respect of its contained pabulum upon which the organisms of caries can thrive, and as the composition of the saliva is dependent upon the food habit, caries is a diathetic expression, and immunity may be secured through correct food habits. According to this view, individuals who consume abnormal proportions of carbohydrates are susceptibles of caries. This is frequently found to be the case, but that notable exceptions are also

found is easily within the experience of many practitioners.

Accordingly, all the facts bearing upon immunity and susceptibility, as well as those related to the localization of the carious process upon smooth enamel areas, are as yet not known. Nor can we say in what manner the problem of general immunity, *i. e.*, immunity to systemic diseases, is related to the problem of immunity to caries and to the formation of the bacterial plaque. It may be that Metchnikoff's theory of phagocytosis, which holds a prominent position among the views offered in explanation of immunity, is involved in the question of immunity and susceptibility to caries as well as the formation of the bacterial plaque. It is definitely known that prior to the phagocytic function of the white blood cells certain substances, *agglutinins* and *opsonins*, so affect the bacteria as to render them entirely passive to the devouring function of the phagocytes. It may be that in some manner these substances, as well as the phagocytes, are related to the problem of carious immunity as well as to the problem of plaque formation.

It is almost unnecessary, at this late date, to speak of the structure of the teeth in relation to dental caries. There appears to be, however, an almost ineradicable tendency to view the hardness or softness of teeth as depending upon the proportion of contained inorganics as the controlling factor in dental caries, and so many patients express themselves in this manner, through the erroneous promptings of dental practitioners, that its denial cannot be too frequently repeated, nor can it be made too emphatic. Since Dr. Black's investigations demonstrated that the variation in the inorganic constituents of teeth was too insignificant to be a factor in immunity or susceptibility to caries, many dentists still

refuse to accept these findings because of the varying resistance of teeth to cutting instruments. But this difference in resistance to cutting instruments is not due to any difference in the percentage of the contained calcium salts, as is commonly supposed. Close clinical observation will disclose that the so-called soft teeth may be immune while the so-called hard teeth may be susceptible to caries. The tooth itself in this sense being a negative factor, the difference in the degree of resistance offered to cutting instruments appears to exist only in the enamel, and is due to the arrangement of the enamel rods. Fig. 9 shows a section of enamel having straight rods running through its entire thickness. Such enamel may be easily broken away. Fig. 10 shows a section of curled enamel; the interlacing of the rods is very easily seen for two-thirds of the thickness. The rods straighten out toward the surface. This

FIG. 9.—SECTION OF ENAMEL WITH STRAIGHT RODS. (Dr. Black.)

form of enamel requires a great deal more force for
cleavage. These differences in the arrangement of

FIG. 10.—SECTION OF ENAMEL WITH CURLED RODS. (Dr. Black.)

rods have nothing to do with differences in the percentage of lime salts that they may contain. Neither is any difference to be observed in the liability to caries. The one decays quite as easily as the other.

In view of the present state of our knowledge of dental caries our efforts should be directed in a conscientious exercise in the preparation and filling of cavities. Recognizing the susceptibility of such portions of the tooth as may offer lodgment to food débris and shelter to bacteria, the margins of the cavity should be brought to immune areas—that is, they should be so extended that all the outlines of the filling can be maintained free of the adherence of food particles and bacteria. This prevents recurring decay. The term "extension for prevention" is now sufficiently well understood by the members of the profession to make its extended treatment in a work like the present quite unnecessary. Conjointly with this method of preparing cavities must be considered the employment of hygienic measures: the periodic removal of all deposits from the teeth, the recognition of the importance of each tooth doing an adequate amount of work, which usually affords also an adequate frictional effect upon the gum. The value of these measures must be duly impressed upon patients that their adoption may aid in the conservation of teeth.

CHAPTER IV

DENTAL CARIES: PATHOLOGY

The beginning of decay takes place upon the surface of the enamel in such locations as afford lodgment to the caries fungi and where the lactic acid which they form remains in contact with the enamel surface, *i. e.*, where it is not washed away by the saliva, or the frictional force of mastication, or brushing. This explains the enamel disintegration at certain points, in distinction to the belief held at one time that the beginning of decay was due to acids suspended in the saliva; if this were so, we would not find, as we now do, its localization upon enamel surfaces. Dr. Black[1] gives these locations, as to frequency of occurrence, in the following order: (1) Pits or fissures, (2) proximal surfaces, (3) the gingival third of the labial and buccal and rarely the lingual surfaces, (4) at or near the gingival, with a tendency to encircle the tooth.

In these locations the bacterial plaque is formed, beneath which the lactic acid begins its decalcifying process; gaining the interior of the tooth substance, sufficient shelter is afforded the bacteria so that, if the protection of the plaque is then lost, the carious process continues. The interprismatic substance which binds the rods together is first removed, followed by that found between the enamel globules which make up the rod. This is followed by a loosening and falling away of the rods.

[1] "Operative Dentistry."

This is the general rule of the order of the carious process. In some instances, as Dr. Black observes, the rods themselves are dissolved. This occurs, at times, in decay beginning in pits, and is due to the prevention of the washing away or dilution of the lactic acid by the saliva, allowing of a greater degree of intensity of action than occurs in other localizations. The carious process does not spread along the surface of pits and fissures because of the interference resulting from the frictional force of mastication, also of brushing, and the washings of the saliva; therefore decays occurring in pits are in the form of a cone with the base against the dento-enamel junction and the apex of the cone toward the surface.[1] Gaining access to the dentin, the bacteria spread along the dento-enamel junction, next to which we find the imperfectly calcified area of interglobular spaces known as the "granular layer of Tomes," also as the "stratum granulosum." These spaces are more numerous in different specimens and afford a quicker penetration of the dentin by the bacteria. The tendency in decay of the dentin is the formation of a conical area with the base of the cone against the dento-enamel junction and its apex directed toward the pulp.[2]

The width of the base will depend upon the ease with which the bacteria may extend along the dento-enamel junction. It also explains why some cavities are wider in relation to their depth than others. As the bacteria multiply the tubes enlarge and finally are destroyed by the bacterial ferments. Figs. 11 and 12 show the penetration of the tubes and their enlargement and the difference to be found in the anastomosing loops which connect the tubes.

[1] Dr. Black, "Operative Dentistry."

[2] *Ibid.*

So far no specific bacterium of decay has been discovered. Dr. Miller assumes that several of the micro-organisms found in the mouth are fitted to produce caries. Dr. Black states that in the deepest portions of the carious area he has found but a single variety, a streptococcus; this he has called "caries fungus" or "streptococcus media," although he agrees with Dr. Miller that several of the bacteria of the mouth have biological conditions which fit them for the production of caries. Fig. 13 shows the *Leptothrix buccalis maxima* and the *Bacillus buccalis maximus* of Miller from the scrapings of an approximal cavity. These organisms are present in carious teeth almost without exception. The *Leptothrix racemosa* of Vicentini, Williams has found almost constantly present in sections of decaying enamel.

FIG. 11.—THE PENETRATION OF THE TUBES BY BACTERIA. (Dr. Black.)

FIG. 12.—THE PENETRATION OF THE TUBES BY BACTERIA. (Dr. Black.)

The first step in the carious process is the removal of the calcium salts of the tooth through the formation of lactic acid. The calcium lactophosphate, calcium lactate and magnesium lactophosphate are formed. In this way the lactic acid, which is the waste product of the bacteria, is removed. If this waste were not removed its accumu-

FIG. 13.—SCRAPINGS FROM DECAYING TOOTH SHOWING LEPTOTHRIX BUCCALIS MAXIMA AND THE BACILLUS BUCCALIS MAXIMUS OF MILLER. x 1500. (Williams.)

lation would soon lead to bacterial destruction. Dr. Miller states that a solution containing .75% lactic acid is sufficient to bring about bacteriolysis. Through osmosis the salts formed by the action of lactic acid upon the inorganic constituents of the tooth pass from the tooth and the carbohydrates contained in the saliva pass through the plaque, furnishing the necessary nourishment for the continued activity of the bacteria. The

lactic acid always decalcifies the tooth prior to the advance of the microörganisms; later the bacterial ferments digest the tubule walls and the organic remnant of the intertubular substance. This occurs at several points, forming what Miller has termed "*liquefaction foci.*" The destruction of the dentin leaves the enamel walls unsupported, which may be still further weakened by the action of the acid from within, termed "*secondary decay.*" When this occurs the enamel wall is readily broken away under the force of mastication. Surrounding the decalcified area may be seen the "*transparent zone,*" concerning the formation of which different explanations have been offered. Several investigators, most notably Miller, regard the *transparent zone* as being due to the vital action of the pulp resulting in tubular calcification, and may be viewed as a protective effort of the pulp against the encroachment of caries. Dr. Black regards it as a decalcifying process. The fact, as pointed out by Miller, that it occurs in vital teeth only offers an apparently sound basis for the vital theory as to the formation of the *transparent zone.*

Upon the proximal surfaces no lodgment is afforded either food débris or bacteria, unless the gum tissue, which normally occupies the interproximal space, is displaced. When this occurs microörganisms soon find lodgment upon the proximal surfaces, and the destructive process, resulting in disintegration of the tooth substance, is early inaugurated. From the central point of the destructive process the tendency is to spread labially and lingually, determined by the washings of the saliva and the friction of the food in mastication, or of the brush. Very rarely indeed the angles of the tooth are crossed. In decays occurring upon the smooth surfaces of the enamel the formation of the conical area is gen-

erally the reverse of what we find in decays occurring in pits and fissures. The tendency is to the formation of a cone with the base on the enamel surface and the apex toward the pulp. These are important points fully to be borne in mind, as Dr. Black emphasizes, in the preparation of cavities for filling.

The positions of the teeth in the two arches, their uses, their forms, and their relation to each other, all bear a positive relation to the inception and spreading of caries. The occlusal surfaces particularly are subjected to thorough cleansings during mastication. This explains why decay, occurring in pits and fissures, does not spread upon the surface, but, as previously stated, when the factors of decay, viz., food débris and bacteria, find lodgment in a pit or fissure, and when the lactic acid, which is soon formed under these conditions, dissolves the interprismatic substance of the enamel, which allows of a deeper penetration by the bacteria, the tendency is to spread in the deeper portions, while the superficial area remains comparatively intact, eventually resulting in a cavity the form of a cone, with the base against the pulp and the apex toward the surface. "These are physical conditions controlling lodgment of débris. They are also physical conditions preventing the removal of anything which may become attached to the enamel in these positions."[1]

Dr. Black calls attention to the great differences to be found in the length of the bucco-lingual approach of the teeth when viewed occlusally. For example, the approximation of the surfaces between the second bicuspid and first molar and the contact is longer bucco-lingually than between the two bicuspids. From this is readily deduced the difference in the form of decay

[1] Dr. Black, "Operative Dentistry."

found between these teeth. In like manner the openings on the buccal and lingual surfaces formed by the rounding of the surfaces of the teeth vary greatly and give rise to differences in cavity forms. When the teeth normally occlude it will be found that the arrangement of the cusps of the upper teeth in their occlusion with the lower teeth, and vice versa, those of the lower molars and bicuspids in their occlusion with the upper teeth, tends to force the food through the openings, or *embrasures,* as Dr. Black calls the openings, in the act of mastication. This rubs the angles of the teeth and accounts for the general immunity to caries which these areas show. Therefore, in the preparation of cavities for filling, the cavity margins should be placed at or near these angles.

CHAPTER V

TREATMENT OF DENTAL CARIES AND PREPARATION OF CAVITIES

The treatment of dental caries may be considered under two divisions—the prophylactic or preventive and the mechanical, which involves the replacement of the lost tissue by a filling.

PROPHYLACTIC TREATMENT

The preventive method consists of the removal of all deposits, collections of food débris and bacteria from the surfaces of the teeth; the use of tooth powders and antiseptic washes, and the utilization of such measures other than named that may aid in preventing the inception of decay. In this relation it may be stated that if subsequent investigations confirm the position recently assumed by Dr. Kirk, to which reference has been made, the correction of abnormal food habits, especially in regard to the consumption of an excessive amount of carbohydrates, may become an important preventive means of dental caries. From the study of the pathology of caries it is quite evident that if the surfaces of the teeth could be maintained absolutely free of bacteria no decay could possibly occur. In a way, this has been indicated in the general freedom from decay which those surfaces of the teeth enjoy which are cleansed by the passage of the food during mastication and the washings of the saliva.

While no system of prophylaxis yet devised can be considered adequate for the prevention of caries under

all circumstances, the general adoption of prophylactic measures (see chapter on oral hygiene) can only be regarded as a factor of great potency in the prevention of dental caries. The authors have a number of families under their care, each member of which receives a monthly appointment for a prophylactic treatment. In each instance the practice has been eminently successful in preventing cavity formations and in maintaining a healthy state of the gum and alveolar structures.

A great variety of instruments have been devised for the removal of deposits found around and beneath the gum margins. Each operator soon learns to employ certain forms most efficiently, so that reference to the different instruments may profitably be omitted. Prior to the removal of the deposits upon the teeth it is well to irrigate the mouth with a 25% borolyptol or similar antiseptic solution. Strips passed between the teeth may materially aid in removing adherent particles of food and masses of bacteria. Wheels of rubber or leather, carrying finely pulverized pumice moistened with hydrogen dioxid, may next be carried over all the surfaces of the teeth or may be applied by means of orange wood carried in hand instruments. In this way all the surfaces may be thoroughly cleansed of all foreign matter. In addition to this the patient must be forcibly impressed with the importance of the effective use of the brush and the value of antiseptic washes and other means of removing particles of food, which, if allowed to remain between the teeth, are so likely to become a factor in the destruction of the integrity of the tooth.

MECHANICAL TREATMENT

The mechanical treatment of caries consists of a consideration of the various steps which have for their ob-

ject the restoration of the lost tooth tissue, together with a due regard for the permanent exclusion of those factors which tend to a recurrence of caries.

There are *two* general classes of cavities—those occurring in pits and fissures and those occurring upon the smooth surfaces of the enamel.

General Principles of Cavity Preparation

The various steps to be considered in filling cavities may be arranged as follows:

1. Removal of weak unsupported enamel walls and extending the margins to immune areas.
2. Removal of decay.
3. Cavity form.
4. Preparation of enamel margins.
5. Final touches.

1. Removal of Overhanging Walls.—With the first step in the filling operation, viz., the removal of weak overhanging enamel walls, other considerations will soon force themselves upon the operator's mind which may materially affect the final result. If the appointment is with a new patient, careful attention should be given to the age and physical condition of the patient. It is manifestly unwise to attempt filling operations so extensive as to be beyond the physical endurance of the patient, and if to this condition is subjoined one of marked tissue hypersensitiveness, an insistence upon proper marginal extension would be most injudicious and most likely lead to an imperfect operation. Under these circumstances it is far better to resort to temporary operations, with less tissue removal, until such time as the condition of the patient improves and he is made more confident by the ease of the first operation, when he willingly will submit to the necessities of a permanent filling. So, too, with

the space which certain operations demand and the consequent pericemental irritation provoked, almost beyond the patient's endurance. It is far better to make use of zinc phosphate and replace it within a year than impose a too severe strain upon the patient, which may tend to a stubborn refusal to submit to future operations through the fear of suffering induced at the first sitting. These as well as other considerations that may influence the character of the operation, and which the dentist learns to quickly dispose of, being settled, the marginal outlines are determined upon as the first step in cavity formation. From the pathological disclosures previously made our practice must be to place the margins of the cavity at such areas as are cleansed by the excursions of food, the washings of the saliva, or as are protected by the gingivæ; if the margin of the cavity lies contiguous to a fissure or pit, or an enamel defect, to cut past this and include it in the outline.

Technique.—The chisel is best suited for the removal of overhanging enamel walls, and if the direction of the rods be borne in mind it is an easy matter to apply force in a direction that will easily cleave the rods. In decay occurring in pits and fissures the bur oftentimes is indispensable. A small size inverted cone bur may be used to effect an entrance through the fissure into the decayed area, and by carrying the bur backward and forward the entire fissure may be conveniently widened. Oftentimes it is necessary to remove the dentin before the enamel can be broken down with the chisel where the margin is to be extended.

2. Removal of Decay.—Having carefully placed the cavity outlines, during which much of the decay of the cavity has also been removed, the second step is the removal of the remnants of the carious dentin. It may be

put down as being axiomatic that all decayed dentin should be carefully removed from the cavity. From time to time controversial discussions appear as to one or the other mode of practice, but from our knowledge of decay of the dentin, safety alone lies in the complete removal of all carious dentin. The plea for the retention of the *decalcified area* which many practitioners make, especially where its removal results in pulp exposure and which no doubt is what those who advocate the retention of carious dentin really wish to express, is quite another matter. Even though the retention of the decalcified area over the pulp may lead to pulp infection, through the utilization of thorough therapeutic measures this complication is rendered highly improbable, and many pulps may be conserved where conservation is important for the future welfare of the tooth.

Where a portion of decalcified dentin is allowed to remain in the cavity, the first step in the treatment consists in neutralizing any remaining acid. A solution of sodium bicarbonate admirably answers this purpose. Next, the cavity is irrigated with sterilized tepid water and thoroughly dried with the aid of a drop of alcohol. A non-irritating germicide is now sealed in the cavity for a week or ten days, for which purpose any of the essential oils may be used, or, what is better, the combination of menthol, 1 part; thymol, 2 parts, and phenol, 3 parts (Buckley). This not only is a powerful germicidal combination, but the thymol imparts to it penetrating power, assuring sterilization. In many cases of deep-seated caries a paste may be made of thymolized calcium phosphate (thymol 10 grs., precipitated calcium phosphate 1 oz., after Buckley) with the above phenol combination, which may permanently remain in the cavity.

The removal of carious dentin is most effectively per-

formed with the use of spoon excavators. With their aid layer after layer of the decayed tissue can be removed without pain or fear of uncovering the pulp. Other forms of excavators, also burs, are at times admissible, but their general use for the removal of decay is attended with the risk of exposing the pulp.

3. Cavity Forms.—The cavity form next demands consideration. This is usually viewed from three aspects—the *convenience form*, the *resistance form*, and the *retention form.*

THE CONVENIENCE FORM.—The convenience form is the form we give the cavity for the convenient placing of the filling material, and while not quite as important as either the resistance or retention form, nevertheless should be fully studied if we seek to obtain most satisfactory results in the filling operation. Cavities in bicuspids and molars involving the proximal and occlusal surfaces are in most convenient form for filling when the resistance and retention form are properly effected. In the anterior region of the mouth the excessive cutting of the labial wall for the purpose of securing the fullest possible view of the cavity is to be deprecated. Extensive cutting of this wall results in unsightly fillings; and while it may be argued that unsightly permanent fillings are better than fillings less unsightly and less permanent, nevertheless, permanent fillings may be secured with a minimum amount of cutting. The lingual wall is not so restricted in this respect. However, a better plan is to provide adequate separation. This will allow of the convenient placing of the filling with least amount of tissue removal. Within the cavity convenience may be secured at the expense of tooth structure, providing always that in so doing no injury is effected. In approximal cavities in incisors and cuspids deepening of the

gingivo-labio and gingivo-linguo axial angles allows of the more convenient placing of the first pieces of gold.

THE RESISTANCE FORM.—By this is meant the form given to the cavity to enable the filling to withstand the stress of mastication. Its importance is proportionate to the filling area exposed to the antagonizing tooth or teeth and varies in different individuals as the force varies with which different jaws are closed. It is secured by forming a *flat seat* for the filling, cut at right angles to the long axis of the tooth, or the direction of the force acting upon the filling. The step of the cavity should also be provided with a flat seat and bear the same angular relation to the surrounding walls as has been given the seat in the gingival wall, unless in so doing the pulp might be exposed. Cavities that involve the incisal surface should be sufficiently deep to allow of a mass of gold that will resist the stress that may be brought upon the filling. No modern doctrine represents a wider departure from former methods than this doctrine of the resistance form of cavities. The crux of former teachings was "No angles" in cavity formation. To-day the prevalent thought is only of angles. The older operators may be reluctant to fully accept this changed view regarding cavity preparation, but it cannot be denied that it appears to be the outcome of a mass of evidence most convincing.

Technique.—Those instruments that cut an angular form are best adapted for the purpose of giving the resistance form to cavities. The inverted cone bur is one of the most useful. The hatchet and hoe excavators and chisels are useful in forming the seat of the filling and giving the surrounding walls the proper angular relation to the seat. The inverted cone bur cuts very quickly,

therefore care should be exercised not to cut too near the pulp.

THE RETENTION FORM.—This is the form given to the cavity which will prevent the filling after its introduction from being dislodged by lateral force. The resistance form, with its flat seat and step, in a large measure guards against the filling being displaced, but it is further necessary to guard against a tipping force which may finally loosen the filling. If the seat of the filling has been cut at right angles to the surrounding walls, and if these walls are parallel or, still better, slightly undercut, the retention of the filling will be secured. In proximo-occlusal cavities in bicuspids and molars the occlusal surface is cut in the form of a dovetail, which is an ideal retention for these fillings. In the anterior region, in proximal cavities not involving the incisal angle, a broadened seat will usually be sufficient for the retention of the filling. When the incisal angle is involved a step should be made, unless the forces acting upon the filling are very slight. But in most cases the step will be necessary if the filling is to be permanently secured in place.

Technique.—Each cavity should be carefully studied in relation to the force which might dislodge the filling. Having carefully considered this and the manner in which it is to be avoided, any instrument which will establish the necessary form may be used. The inverted cone or any of the various excavators may be used. It is useless to denominate the special forms of instruments which operators should use. Each one soon acquires certain preferences, and in his hands these instruments are better agents for the desired end than any others.

4. Preparation of the Enamel Margin.—The preparation of the enamel margin demands as much earnest ef-

fort and studious consideration as any of the foregoing steps in cavity formation. If the joint between the filling and margin of the tooth be improperly made, the filling cannot endure even though every other consideration is carried to the highest standard. The histology of enamel must be perfectly known to the operator if the margin is to be made perfect. The rods of the enamel generally incline from the center of the tooth to the surface, so that they are perpendicular to the surface at nearly all points. In some portions of the tooth they deviate from the perpendicular position and incline at an angle. At the cusps

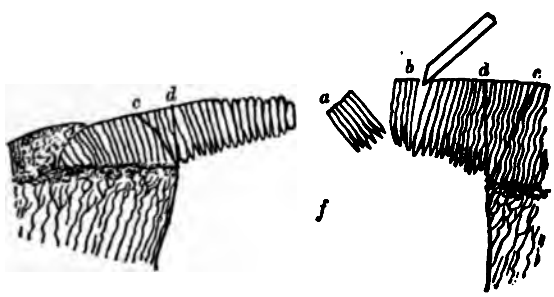

FIG. 14.—ENAMEL CLEAVAGE. (Dr. Black.)

of bicuspids and molars, also at the gingival region this inclination is greatest. At the cusps the rods are parallel with the long axis of the tooth; at the gingival region the inclination is toward the root. Unless the cavity margin is in the proper direction and unless the outer ends of those enamel rods having no support are removed, they are liable to fracture under the act of condensing the gold or the force of mastication and produce an imperfect margin. Fig. 14 will illustrate this. If the rods are cut so as to leave them as shown at *d* they will break away, as they have no support. They should be cut as shown at *c*. Care must also be taken not to give the rods a rounded edge, as this would result in a feather

edge to the filling that would flare up under the forces acting upon it. The angle of the bevel as it should be has been measured and Dr. Black gives it at from six to ten centigrades from the plane of the enamel wall.

Technique.—A variety of instruments, as a rule, are necessary for forming the enamel bevel. If the disk is used, in trimming proximal cavities, care must be exercised not to make the margin rounded by pressing the disk against the wall. At the gingival wall it is almost impossible to make use of the disk and secure the proper kind of a margin. In this region the chisel, or bur, may be used for trimming the margin. The use of the various styles of chisels will be found most convenient in these locations. In small fissure cavities and in cavities occurring upon the labial, buccal, and lingual surfaces the bur is the only instrument that can be used. In all cases the margins should be carefully examined if permanent results are to be attained.

5. Final Touches, or, Toilet of the Cavity.—The final step in the preparation of the cavity involves a critical examination of the margins and the tissue overlying the pulp. The margins should be freed of any adhering particles by carefully going over them with cotton, either dry or moistened with alcohol. It is also well to flood the cavity with a non-irritating antiseptic; the cavity is again dried, and if the dentin overlying the pulpal region is in satisfactory condition the filling may now be placed.

Application of Principles

The foregoing considerations are the underlying principles in cavity preparation. These principles may now be applied in the treatment of specific groups of cavities considered in the following order: (1) Cavities beginning

in pits and fissures. (2) Cavities beginning in the proximal surfaces of bicuspids and molars. (3) Cavities beginning in the proximal surfaces of incisors and cuspids, not involving the incisal angle. (4) Cavities beginning in the proximal surfaces of incisors and cuspids, involving the incisal angle. (5) Cavities beginning in the gingival third occurring upon smooth surfaces.

1. Preparation of Pit and Fissure Cavities.—These cavities, as a rule, are accessible, so that very little difficulty is usually encountered, either in the preparation of the cavity or the insertion of the filling. The superior third molar, at times, is an exception to the rule. The cavity may be opened by using a fine fissure or inverted cone bur until the fissure has been widened its entire length. Usually not much softened dentin is found in these cavities, but all affected portions should be removed. If the decay has undermined the enamel walls, such walls should be chiseled away until supporting dentin is reached. It is necessary to include all pits and fissures in the outline form, so that the margins of the cavity may be placed at such parts of the tooth as will enable the operator to give a perfectly smooth finish to the filling. The resistance and retention form are easily secured by carrying an inverted cone bur forward and backward, so as to form a flat pulpal wall with definite angles in its relation to the surrounding walls, which should be cut parallel with each other.

Most operators prefer giving all cavities a form slightly larger within than without. This precaution is entirely unnecessary in pit cavities where the depth of the cavity exceeds the diameter. The pit cavities on the lingual surface of the superior incisors generally are found so shaped after the decay has been removed. If the walls are parallel the resistance which they offer is

sufficient for the permanent retention of the filling. The enamel margin should have a slight outward bevel, or the bevel may be entirely omitted if the walls of the cavity are cut at right angles to the plane of the enamel surrounding them. *The final touches* are now accorded the cavity, after which it is ready for the filling. At times a fissure cavity is opened which is found, upon removing the decay, to have extended quite close to the pulp, it being easily recognized that, unless protection be accorded the closely lying pulp, irritation must ensue through thermal shock through the filling. The complications following the excessive loss of dentinal substance may be viewed from several standpoints. As has been intimated, thermal shock through the metallic filling may lead to pulp irritation, or the pressure of the filling upon a thin section of dentin may provoke it, or the use of irritating chemical agents, an example of which may be found in the phosphoric acid of the cement placed over a thin layer of dentin, may also lead to painful manifestations expressive of pulp irritation. Thoughtful attention must be given to these various possibilities if future complications are to be avoided. If the cavity is of such depth that it appears expedient to replace a portion of the lost dentin with a layer of zinc phosphate, prior to placing the zinc phosphate, an impervious varnish should be applied to the dentinal walls. This protects the fibrillæ and pulp from any irritating impress that the zinc phosphate may exert. Rubber varnish or Cavitine may be used for this purpose. Applied in several layers, allowing each layer to dry before placing the following one, either preparation is fully capable of preventing either thermal or chemical irritation from passing into the pulp.

2. Cavities beginning in Proximal Surfaces of Bicuspids and Molars.—In considering the preparation of

cavities occurring upon the smooth surfaces of the teeth, it is well to bear in mind the pathology of caries so as to forcibly bring out the reasons for the emphatic insistence of investigators, headed by Dr. Black, that in the preparation of cavities the margins should be extended to immune areas. It has been pointed out that in decays beginning in pits and fissures there is no surface extension of the carious process because the surface area is kept clean by the washings of the saliva and the frictional effect of mastication. A section of a tooth through a carious fissure or pit shows a conical area with the base of the cone toward the pulp and the apex toward the surface. In other words the extension of the decay has been within and not along the surface.

In decays occurring upon the smooth surfaces of teeth it has been found that the converse of the above is the rule. The extension is along the surface until it reaches such parts as are kept clean by the excursions of food during mastication. In other words, the decay extends along the surface until it reaches the angles. Therefore, the rational method of procedure, in the preparation of smooth surface cavities, is to extend the margins to the angles of the teeth so as to bring the margins of the fillings to immune areas. Dr. Black[1] records that of 10,000 patients examined but 9 showed spreading of caries across the angles. Such evidence cannot be ignored, and has led to the doctrine of "Extension for Prevention."

In preparing cavities the relation of the proximal contact has to be considered as a factor in extending the margins. Fig. 15 shows a cavity in the proximal surface of a bicuspid. Fig. 16 shows the same cavity after the weak enamel walls have been removed. Fig. 17

[1]"Operative Dentistry," Vol. II.

shows the cavity prepared for filling with the occlusal step formed for the retention and resistance of the filling. Fig. 18 shows the cavity filled. Fig. 19 shows the


FIG. 15.


FIG. 16.


FIG. 17.


FIG. 18.

contact of the tooth with the molar, and Fig. 20 clearly shows that in this case the margins have been sufficiently extended for proper cleansing by the passage of food


FIG. 19.


FIG. 20. (After Dr. Black.)

during mastication. If the proximal contact of the teeth had been wider it would have necessitated a wider extension.

The occlusal step, as shown in the illustration, is a necessary feature of the cavity preparation, because it affords the filling greater resistance to stress and provides for its better retention. This has been previously noted.


FIG. 21. (After Dr. Black.)

Fig. 21 shows a wider proximal contact than in the preceding illustration. Here the plan of preparation must be somewhat different if the integrity of the filling is to be permanently maintained. In this case it is necessary to secure suffi-

cient separation so that a *prominent contact*[1] can be formed, one that will allow of a thorough cleansing during mastication. Fig. 22 illustrates this. Fig. 23 illustrates the same case with a wider extension. This also

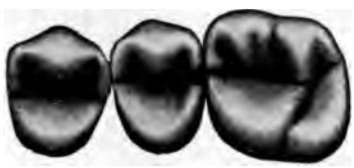

FIG. 22. (After Dr. Black.)

FIG. 23. (After Dr. Black.)

allows of a thorough cleansing of the margins during mastication.

The problem with simple cavities on the proximal surface in bicuspids and molars is often very trying. Shall the cavity be prepared so as to bring the margins to immune areas? Or, shall the cavity not be so extended? At times it is difficult to conclude one way or the other. The age of the patient, the physical condition, and the conditions of susceptibility and immunity should determine what is to be done. Most operators can quite readily conclude in what cases they would care to undertake the extension of a simple cavity in the proximal surface of a bicuspid or molar so as to bring the margins to self-cleansing areas; only when all the conditions are favorable would they affirmatively conclude—that is to say, when the tooth structure is not hypersensitive, when the operation would entail no serious physical tax upon the patient, and when the existing condition of susceptibility to decay would strongly argue for such extension. Otherwise most operators would quickly conclude not to extend the cavity; they would prefer to do temporary work until such time as the factors would be more favorable for the extended operations.

[1] Black, "Operative Dentistry."

3. Cavities in the Proximal Surfaces of Incisors and Cuspids, not involving the Incisal Angle.—The operator very quickly learns that a good filling can only be made if the necessary accessibility has been secured, and to gain this the teeth must be wedged apart, either by the mechanical separator or the use of various materials capable of separating the teeth. As a rule, the use of the mechanical separator will prove to be too inflictive if used to the extent of securing a convenient separation. It is better to allow several days for the attainment of the separation and the use of a material which moves the teeth apart slowly. Having secured the separation, the weak enamel walls are broken down and the decay removed from the cavity. The convenience form is now provided for. The separation of the teeth does not provide this. The cavity margins must be extended lingually so as to afford direct approach to the cavity. Labially the margin is extended to a self-cleansing area. The gingival margin is carried beneath the gum tissue, and the incisal margin should be extended far enough incisally, so that when the filling is completed the margin of the filling in the incisal region can be kept cleansed.

If we study the cause of the frequent failure of these fillings we find that the margins were either not properly prepared, or not sufficiently extended. The recurrence of decay is most frequently seen at the linguo-gingival and labio-gingival angles and near the incisal angle, due to the failure to place these portions of the fillings at self-cleansing areas. It is in view of the many failures occurring upon the proximal surfaces of incisors and cuspids and the determination of their etiology that the *extension for prevention* doctrine insists upon a sufficiently broad gingival margin, and a sufficient incisal extension, that the vulnerable parts of the filling may reach such

portions of the tooth as are cleansed by the excursions of food, the friction of the brush, the washings of the saliva. The gingival margin is protected by the gum tissue. The proper *retentive form* in these cavities is sufficient for the *resistance form,* and is secured by forming a broad flat gingival seat cut at right angles, or nearly so, to the labial and lingual walls and forming a slight undercut in the incisal region. Care must be taken not to remove all of the dentin in the incisal region, as the unsupported enamel is likely to break away in packing the gold, or from the stress of mastication. It is for this reason that many operators prefer not to use a bur for the formation of the incisal undercut. The enamel margins are next carefully beveled and polished, the final touches given the cavity and the filling inserted.

Small cavities occurring upon the proximal surfaces of incisors and cuspids should receive the same sympathetic consideration accorded those found on the bicuspids and molars. If the cavity can be enlarged so as to place the margins where they ought to be placed for permanent results, without imposing a too serious strain upon the physical condition of the patient, that naturally would be the first choice. If, however, the conditions do not allow of proper preparation, then it is far better to insert a gutta percha or zinc phosphate filling, acquainting the patient with the temporary character of the operation and suggesting a permanent one in its place at the first favorable opportunity.

4. Proximal Cavities in the Incisors and Cuspids involving the Incisal Angle.—When decay upon the proximal surface of the anterior teeth has extended so as to weaken the incisal angle its removal becomes imperative, and the plan of procedure for the preparation and filling of the cavity is dependent in a measure upon several

factors. The thickness or thinness of the incisal surface, the force of the occlusion, the articulation, the age of the patient, may determine the character of the operation. In dealing with this class of cavities we shall leave out of consideration those cases in which pulp removal is necessary and in which the anchorage is made in the pulp chamber. The removal of the pulp for the purpose of securing the necessary anchorage for the filling is surely followed by the loss of translucency of the tooth, which in many cases would make this a matter of serious objection, so that almost any other alternative, excepting the loss of the tooth, would be more acceptable. The removal of the pulp for the purpose of securing adequate anchorage for the filling, however, is so seldom necessary that it does not deserve more than passing notice. Each operator soon learns in what cases he would prefer this to the placing of a porcelain crown upon the root, and almost all would prefer to exhaust all other methods of securing this class of filling operation before devitalizing.

In young patients with thin teeth, very little wear upon the incisal edge, and a weak occlusion, the preparation is upon the plan given for those cases where the incisal angle is not involved. The seat of the filling is made as before, but somewhat broader and longer, to better withstand any additional strain. Special precaution must be taken not to remove all dentin in preparing the incisal undercut, and to make this sufficiently deep, that it will allow of the use of a great enough bulk of gold to withstand the forces acting upon it. Slight undercuts may be made in the labial and lingual walls. The margins are suitably beveled, and after the last touches are given the cavity the filling may be inserted. The operator should always aim to restore the full form

of the tooth. This is imperatively necessary. Fig. 24 illustrates this class of cavity preparation. It will be noted that the incisal retention is not far removed from the incisal edge; nevertheless it is usually sufficient, owing to the character of the articulation and occlusion.

A second mode of preparation may be practiced in thin teeth of young patients. This resembles the previous plan of preparation in all excepting in the incisal retention. In this method a dovetail is cut into the lingual surface in place of cutting between the labial and lingual walls, as is done in the first method. The dovetail may be extended to include the pit located upon the lingual surface, and, as this is usually involved in the carious process, its inclusion at this time eliminates a subsequent operation in this region. Fig. 25 illustrates this method of cavity preparation.

FIG. 24.

FIG. 25.

A third mode of preparation applies to those cases where both the lingual wall and incisal edge are badly decayed. In these cases a step is cut in the incisal surface, sufficiently deep to withstand the forces acting upon it. A frequent cause of failure of these fillings is found in the deficient depth given the step, resulting in a thin layer of gold, which is quickly beaten out of shape. In preparing the step the nearness of the pulp must also be taken into account; however, in all cases sufficient depth must be provided that will enable the filling to withstand the force of mastication. Dr. Black advises the removal of the pulp in those cases where its close proximity interferes with the proper form being given the incisal retention. Fig. 26 illustrates this plan of cavity formation. In cases where the teeth meet edge to edge,

and the dentin is exposed, the proximal cavity is prepared in such manner as will include the incisal restoration. In these cases the step is carried along the entire length of the incisal edge; the labial and lingual walls are beveled toward the pulpal wall of the step, so that the entire surface is protected, including the incisal enamel, which otherwise will chip away from the forces acting upon it.

Fig. 26.

5. Cavities in the Gingival Third of Labial, Buccal and Lingual Surfaces.—These cavities occur at a point near the gum margin and become more difficult to manage as we progress posteriorly, although not any of the decays should present very serious obstacles to successful preparation and filling, with the possible exception of those occurring in the *third molar.* In the past, fillings in these cavities failed because the pathology of caries was not made out then as well as it is to-day. It was not known that if the margins of these cavities were properly extended decay would not recur. Fig. 27 shows decay at three separate places in the gingival

Fig. 27.

Fig. 28.

Fig. 29. (After Dr. Black.)

third of a molar. Fig. 28 shows the manner of cavity preparation, and Fig. 29 shows the completed filling. The first illustration clearly shows the whitened area surrounding the three cavities. Unless this is looked

for by placing the tooth under the rubber dam and drying the surface, it is likely to be overlooked in the preparation of the cavity, making the margin of the cavity directly in this weakened zone and inviting early failure. If, however, the margins are extended toward the angles of the tooth, as shown in the illustration, we place them at immune parts. If, to this, is added the precaution afforded by proper brushing, so as to keep the margins properly cleansed, even in cases of susceptibility to caries, permanent operations can be made. Another fact to be kept in mind when preparing cavities for filling is that decay does not occur along the margin of a filling if it is covered by healthy gum tissue. Therefore, in the preparation of these cavities, the gum should be pressed away, so that the gingival margin can be placed beneath the border of the gum. These cavities do not require deep cutting for retention; a slight undercut in the gingival and occlusal walls is sufficient, even in shallow cavities.

CHAPTER VI

THE TREATMENT OF THE DECIDUOUS TEETH

A limited experience is sufficient, as a rule, to impress upon the dentist the importance of conserving the deciduous teeth until their permanent successors are in position in the arch. The direful results that usually follow the early loss of the deciduous teeth are sure to impress themselves upon the notice of the beginner in the practice of dentistry. In view of this, the care of the deciduous teeth is a matter of serious study with the conscientious practitioner, for it appears to him as a phase of practice not exceeded in importance by any other. Unfortunately the control of the condition does not rest entirely with the dentist, otherwise many of the noted injurious consequences would be averted. The young patient usually presents a stubborn unwillingness and antagonism to our efforts which, in nearly all cases, frustrate the plan for permanent operations, and frequently, unless we have at our command almost infinite patience, judgment, and gentleness, defy all attempts at operative procedure. Most children appear to labor under the influence of an unusual sense of fear of the dentist and dental instruments, due, in a large degree, to imprudent conversations of the members of the family concerning the great pain of recent dental operations. Such narrations before children will surely develop in them a fearsomeness, at times uncontrollable, and at all times admitting only of imperfect operations.

It is quite evident, then, that our first efforts should be directed in a manner positively preclusive to any infliction. This cannot be too emphatically stated, nor can it develop an undue amount of caution. It is far better to make but an examination, or else introduce into a cavity a pledget of cotton carrying a drop of the oil of cinnamon, the taste of which is agreeable to most children, than incur the risk of preparing and filling the simplest cavity, unless absolutely certain that this can be done *without pain.*

Furthermore, it is quite evident that at times it is better to proceed under faulty methods, which would not be admissible in the case of older patients, rather than proceed more perfectly, if in so doing the procedure becomes inflictive. In this way alone the child's confidence can be won. In fact, it is quite probable that under skillful guidance the most fearsome children may be made, in time, to look upon their visits to the dentist with a degree of pleasurable anticipation. Coercive measures should never be employed by the dentist; so, too, would it be manifestly imprudent to be a party to *deception.* In the case of obstreperous children parents suggest one or the other as means of overcoming the stubborn resistance offered by the child. To either proposition the dentist must maintain an inflexible opposition. In other words, we must make the child conscious of a sympathetic and affectionate regard if we hope to develop its assurance and confidence, and without these we are powerless to do any good.

There appears to be a general concurrence of the views of writers that, as the deciduous teeth are retained in the arch but a few years, and, furthermore, as the conditions under which our therapeutic aid is rendered are not conducive to best results, the plastic

filling materials are best suited for filling cavities in deciduous teeth. Experience apparently sustains this position.

For proximal cavities in the incisors and cuspids either gutta percha or zinc phosphate may be used. If the form of the cavity is not favorable for the retention of gutta percha, and where it is not advisable to insist upon giving the cavity a better retentive form, zinc phosphate is the material *par excellence.* When using it the information should be conveyed that its service in most instances is not beyond one year, and that most probably several renewals will have to be made. Nevertheless, by its use the tooth can be preserved until its successor is in place, and this is preferable to the complete failure which surely follows any attempt to suitably prepare a cavity for the retention of a more permanent material, if in so doing we inflict pain. In many cases, upon removal of the decay, we find the cavity form favorable for the retention of gutta percha. In these instances our choice should rest upon the use of this material in preference to zinc phosphate. In proximal cavities not exposed to the forces of mastication permanent results may be secured in the use of gutta percha that are most gratifying. Some dentists prefer the use of the pink base plate gutta percha; this, also, is an excellent filling material, but does not possess a single advantage over a good grade of white gutta percha, and its color, especially for the anterior teeth, is not nearly so good.

Cavities in molar teeth may be filled with amalgam, zinc phosphate, gutta percha, copper phosphate, and, as some writers claim, tin foil. Amalgam is likely to give best service, providing that the cavity can be properly prepared; otherwise it will miserably fail. The oxy-

phosphate of copper holds out the promise of proving to be an excellent filling material for the deciduous teeth; its color limits its use to the molar teeth, and for permanency it seemingly outranks zinc phosphate. Where we have two proximal cavities in the molars that open into each other, it is good practice to fill them with one filling made of gutta percha, with a metal guard at the gingival border to prevent the filling from being forced into the interproximal space. Fig. 30 illustrates this.

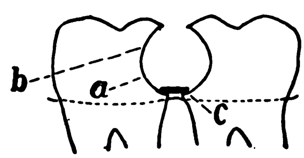

FIG. 30.—a, b, Cavity margin; c, metal guard for gutta-percha filling.

Dr. Bonwill claimed that gutta percha, used in this manner, exerted lateral pressure through the force of mastication favorable to the development of the arch. The other filling materials cannot be utilized in this manner of bridging two cavities. Their rigidity after setting, and the movement of the teeth under the force of mastication, would soon result in the separation of the filling from one or the other tooth wall, and the early reappearance of decay. Fissure cavities are most permanently filled with amalgam. If, for reasons noted, it is impractical to properly prepare these cavities for amalgam, zinc or copper phosphate may be used, and perhaps at a later period a more permanent material may be utilized. Frequently hypersensitive tooth structure disappears under these fillings, and what at first was an impossible operation, owing to the hypersensitive state of the dentin, later on, after dissolution of the cement filling, is easily accomplished. Temporizing, under these conditions, may at times be good practice and lead to permanent results, which could not in any other manner be secured.

Dr. Stebbins[1] calls attention to the use of silver nitrate in the treatment of deciduous teeth; shallow cavities that do not admit of the placing of any filling, and that are too sensitive for further preparation, may be treated in this way. It is claimed that the action of the silver salt upon the dentin results in the formation of silver albuminate, which temporarily protects the tissue from caries. In deep-seated cavities of deciduous molars, rather than expose the pulp through the removal of all affected dentin, a piece of blotting paper saturated with a strong solution of silver nitrate may be placed at the bottom of the cavity, and over this is placed the filling. The experiences of many testify to the value of this method of treating deep-seated caries in *deciduous teeth,* in preference to that of removing the pulp.

Pulp conservation of the deciduous teeth does not appear to be a successful mode of practice with most practitioners. On the other side, it may be said that pulp removal is also attended with unfortunate consequences. It has been previously noted that pulp removal of the deciduous teeth is usually followed by an interference with the function of the resorbent organ. The cause of this has also been previously noted (see Dentition). Therefore, it appears to be, mainly for these reasons, the rule with many, in treating deep-seated caries, not to devitalize the pulp, thus avoiding its removal, also the risk attending the interference with root resorption; instead, the case is treated with silver nitrate, as indicated above, and over this the filling is placed. This method only appertains to the treatment of deciduous teeth. Under no circumstances is this plan to be followed in the treatment of permanent teeth. Here

[1] *International Dental Journal,* 1891.

every particle of decay must be removed, even though in so doing the pulp is exposed.

If pulp capping has been decided upon in treating deciduous teeth, a paste made of zinc oxid and a drop of one of the essential oils is placed within a concave metallic disk, and very gently laid over the exposure. The avoidance of pressure is the great desideratum in the conservation of exposed pulps. With the capper in position, the parietes of the cavity are varnished with *cavitin,* or *rubber varnish,* and zinc phosphate or copper phosphate is flowed into the cavity and allowed to harden.

In many instances in which the pulp becomes exposed through the carious process, it is best to remove it. This can be done under cocain and pressure, or substituting an anodyne, such as camphophenique, or one of the essential oils, for the cocain, and this plus pressure are the means usually employed to effect pulp removal. It is well to avoid the use of arsenic in deciduous teeth, owing to the enlarged apical end, and the probability of the arsenic being carried through, if allowed to remain in contact with the pulp. The most extensive case of coagulation necrosis seen by the writers was due to an application of arsenic to the pulp of the first permanent molar, and its subsequent escape through the apex, owing to incomplete root formation.

With the removal of the pulp, the canals may be filled with a cone of temporary stopping, or gutta percha, previous to which the canals are wiped with chloropercha and eucalyptol. Care should be exercised not to employ too much force in inserting the root filling; otherwise an apical irritation may be set up which might lead to the early loss of the tooth. The combination previously suggested for the capping of exposed pulp

will also be found to give excellent results, viz., zinc oxid made into an inspissated paste with campho-phenique, or one of the essential oils. When the canals are filled with this combination a layer of temporary stopping is placed over the entrance, followed by the filling. Aseptic precautions must be rigorously enforced during the operation; therefore, the dam should be in position. Unless thorough aseptic precautions are taken failure will surely ensue.

The treatment of the *first permanent molar* may be conveniently considered under the present chapter. This tooth usually appears in the arch at about the time the child first seeks dental aid, and, as it is early attacked by caries, unless carefully guarded, its early loss may be followed by irreparable injury. Many instances of permanently impaired occlusion and alteration of facial lines can be directly traced to the early neglect of the first permanent molar. This tooth usually appears in the arch at about the sixth year, and its great importance must be duly impressed upon the parents, so that it might not be so seriously impaired through neglect as to lead to its early loss. Caries usually attacks this tooth quite early in life, and for reasons similar to those noted in relation to the preparation and filling of cavities in deciduous teeth, we may be unable to permanently fill the first permanent molar until the child is several years older. Until then the sulci may be filled with zinc phosphate, or, what appears to be still better, copper phosphate. These fillings should be examined at stated intervals, and renewed when necessary, that the tooth might be conserved, and, under more favorable conditions, permanently filled. This method of treating the first permanent molar is adopted in preference to the attempt to prepare the tooth for a permanent filling at

a time when all the conditions are antagonistic to the success of the endeavor, and when insistence upon utilizing a more permanent filling is likely to lead to failure and early loss of the tooth.

CHAPTER VII

INLAYS: INDICATIONS FOR THEIR USE, AND THE CAVITY FORM

Recent developments in inlay work have been followed by a wave of enthusiasm almost unequaled in dentistry. The history of our profession is replete with instances showing that, whenever a too enthusiastic reception was accorded a new mode of practice, within a short time there usually followed a backward swing which carried the profession almost as far backward from its normal poise as it was carried forward by its enthusiasm. To what extent the present enthusiasm accorded the cast inlay will be modified by subsequent experiences remains to be seen; instances are not lacking which indicate that, in some quarters at least, disappointment has taken the place of enthusiasm, while in others, especially those characterized by conservatism, the practice appears to find as much, if not greater, favor as when first introduced. It is not unlikely that this difference of attitude may be due to differences in the mastery of the details underlying the practice, for it can most emphatically be stated that no method of operative procedure requires a greater mastery of the related details than that of inlay work, if permanent results are desired.

Inlays are of two classes, *porcelain* and *gold*. The gold inlay may be subdivided into the *matrix filling* and the *cast filling*.

The porcelain inlay has been before the profession for many years. About ten years ago the practice received renewed impetus by the work of Dr. Jenkins, which popularized low fusing body, admitting of the use of gold for the matrix. Since then almost endless discussions have appeared as to the relative merits of the high and low fusing bodies, with the argument apparently in favor, at least with the American dentists, of the high fusing body. Inlays prepared from either kind of body have answered all reasonable tests, and it may further be stated that, in cases demanding *esthetic considerations,* the porcelain inlay is without an equal. In the face of its well known attribute of *brittleness,* the solubility in the fluids of the mouth of the material with which the inlay is held in place, and the defectiveness which may be summed up in the "color problem," the porcelain inlay will remain in high repute with many dentists, as well as patients, where esthetic considerations are of paramount importance. Many failures resulting where porcelain has been used have been due to the disregard of two important points: firstly, that it is impossible to secure as effective an anchorage with an inlay, whether gold or porcelain, as with a properly introduced metallic filling, and, secondly, the quality of brittleness of porcelain, which results in fracture along the margin, inviting lodgment of food débris and bacteria, and leading to failure. These conditions cannot be overlooked if permanent results are sought; to this must be added the necessity for correct cavity preparation, as otherwise failure will ensue, even though the other conditions have been held in view.

The fundamental principles of cavity formation for an inlay are the same as those for gold fillings. The outline form is the same, excepting where this is en-

larged to secure greater bulk for strength when porcelain is used. The same principles apply as to the resistance form, the removal of the decay, and the final touches. The retention form is entirely different. The cavity must be planned so that the matrix can be removed without the slightest distortion. The preparation of the margin is also different when porcelain is used. Here the margin should be cut straight, that is, at right angles to the surface, that the inlay may meet it with the same kind of an angle. This gives the strongest kind of an edge to a porcelain inlay.

Cavities Beginning in Pits and Fissures.—In these cavities the rule is to exclude porcelain for obvious reasons. They are not prominently exposed to view, therefore the esthetic quality of porcelain is not imperatively demanded. Furthermore, its brittleness contraindicates its use in these locations, the majority of which are exposed to the stress of mastication; and, as these cavities may be filled very effectively with either gold or amalgam, the rational procedure is to use either of these materials, and not incur the risk of almost certain failure that attends the use of porcelain. In large occlusal cavities in molars, those in which the introduction of a foil filling is hazardous, because of an impaired pericementum, or because the operation is beyond the patient's physical endurance, Dr. Black[1] recommends the gold inlay.

Cavities in the Proximal Surfaces of Bicuspids and Molars.—In these cavities porcelain has not given a good account of itself, and unless *esthetic reasons demand its use*, irrespective of its durability, the gold inlay is likely to give better results. If porcelain is used, the cavity must be prepared in a way that will allow of sufficient

[1] Black's "Operative Dentistry."

bulk to the filling. In many cases this leads to a too close approximation to the pulp, resulting in its pathological involvement. The use of porcelain in this class of cavities calls for the closest attention to every detail of correct cavity preparation, also for wide separation, and, when these demands are fully met, even then assurances of good results are not securely founded. The cavity for the gold inlay may require just as careful planning in its final preparation, the wide separation may be just as necessary, but, when these demands have been met, these fillings are much more likely to give permanent results. Proximal cavities in bicuspids and molars are prepared similarly for the porcelain or gold inlay, excepting that the margin is not beveled, as previously indicated, when porcelain is used, and the occlusal step is cut deeper to gain bulk of porcelain for strength. The gingival seat is enlarged to the fullest extent, and the occlusal step slightly dovetailed, so that when the inlay is placed in position it will be held against lateral displacement. In bicuspids from which the pulp has been removed no difficulty is experienced in securing retention or bulk, and, where the case calls for a mesio-occluso-distal restoration, the buccal cusp may be cut away and replaced with porcelain. This enables the operator to make a stronger filling, and one securely anchored.

Cavities in Proximal Surfaces of Incisors and Cuspids which do not Require the Incisal Restoration.—Sufficient space must be provided in these cavities so that the inlay can be placed in position when completed. This necessitates extending the labial or lingual margin to the axial wall. If either the labial or lingual wall has been weakened through decay, the choice will fall to the wall so weakened, and this is cut away to a line that will

admit of the insertion of the completed inlay. The removal of the labial wall may also be made necessary through loss of its supporting dentin. If this is not done the cement used in setting the inlay will almost invariably destroy its esthetic effect. It is a good rule to exclude the gold inlay from the incisors and cuspids. Occasional exceptions to this rule may be noted, as, for example, a case which came under the writers' recent observation. In this instance almost the distal half of the superior cuspid had been lost through caries and subsequent fracture, and the forces of mastication were too great to be successfully resisted by a porcelain inlay, as fracture of the tooth attested. The restoration was too large for a foil operation, and was later successfully made with a gold inlay. In the preparation of these cavities the incisal and gingival walls are cut flat and quite parallel with each other, just flaring out in the proximal direction sufficiently to allow of the removal of the matrix. The lingual opening should not be as wide as the labial, so that the inlay, when finally set through the labial opening, will just reach its proper place.

Cavities in the Proximal Surfaces of Incisors and Cuspids which Require the Incisal Restoration.—These cases at all times severely tax the judgment and skill of the operator. In proportion as the restoration is prominent, so does the necessity for esthetic effect exist, and this is best secured through the use of porcelain. If porcelain is used, too much time cannot be consumed in the preparation of the cavity, in order to secure sufficient bulk for the inlay and the proper anchorage for its permanent retention. Many of these restorations have given most excellent results; on the other hand, many failures have been recorded, a large proportion of

which resulted from failure to properly appreciate all the details necessary for a permanent operation. Again, failure has persistently followed some cases, planned with the greatest care, due to the inability of the inlay to withstand the forces acting upon it. Of these some may be satisfactorily restored with the gold inlay; others will require a foil filling. In all cases it is well to acquaint the patient with the difficulties and uncertainty of the restoration; in this way subsequent unpleasantness may be avoided. Many patients will prefer the use of porcelain to that of gold in the face of all unfavorable prognostications.

In preparing the cavity its form will depend upon the conclusions reached after a careful study of the forms of the teeth, the character of the forces acting upon the tooth, the occlusion, and the extent of the decay. In most cases it will be necessary, for the security of the inlay, to cut a step extending along the incisal surface, and this must be formed so as to provide the inlay with sufficient bulk to resist the stress of mastication acting upon it. Most failures of these inlays are due to the improper depth given the step portion of the cavity. There are some cases, however, that may be repaired with porcelain, which do not require the incisal extension. Fig. 31[1] shows a proximal cavity in an incisor with the incisal angle fractured. The forces acting upon the tooth are not severe. By forming a broad gingival seat for the inlay, with the incisal portion of the cavity cut almost parallel, an inlay may be constructed that will fully restore the contour of the tooth and prove to be very serviceable. If the enamel in the incisal region is in the slightest degree impaired this method of making the restoration is not advisable.

[1] Johnson's "Operative Dentistry."

In these instances it is better to shorten both the labial and lingual enamel fully one-half the width of the incisal surface, and make a step restoration. The removal of the labial enamel at all times is a procedure requiring the finest discrimination. The tendency to conservatism in this regard frequently invites failure, and, on the other hand, the extensive removal of the enamel plate, to secure bulk of material, results in extensive restorations, many of which, even though the greatest care may have been exercised, are unsightly, while others end in failure. Fig. 32 illustrates the lingual prepa-

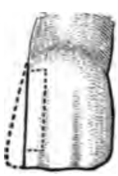

FIG. 31.

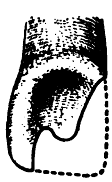

FIG. 32.

FIG. 33. (After Johnson.)

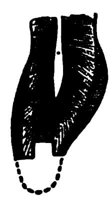

FIG. 34. (After Johnson.)

ration of the cavity. It is formed to prevent lateral displacement of the inlay.

RESTORATION OF THE INCISAL SURFACE.—Teeth that are marred in the incisal region, through imperfect development, may be made to appear to better advantage by the use of a porcelain section, planned to restore the imperfect portion of the tooth. These operations are beset with many difficulties, which at times are insurmountable. Fig. 33 illustrates the preparation of the edge. This form of restoration allows insufficient bulk to the inlay in its middle portion resulting in many instances in failure.

Fig. 34 illustrates another form of preparation which allows of a stronger restoration, but which involves the danger of encroaching too closely upon the pulp. It is

quite evident that this must be carefully avoided, as the complications following pulp involvement are too serious not to be positively guarded against. Other modes of restoring the incisal edge may be followed; these usually include the use of platinum pins, or loops, and provide more satisfactory means of attachment for the inlay. These should be given the preference, if they can be constructed without impairing the strength of the porcelain section. Figs. 35 and 36 illustrate these methods.

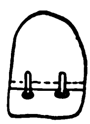

FIG. 35

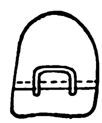

FIG. 36.

FIG. 37.

FIG. 38.

The pins or staple may be soldered to the platinum matrix with pure gold, or they may be held in position with a mixture of the porcelain body, water and gum tragacanth.[1]

Cavities in the Gingival Region upon the Labial and Buccal Surfaces.—In these cavities porcelain has given the very best results, and, for esthetic considerations, it is especially indicated in the labial cavities. The floor of the cavity is cut straight; this provides a suitable seat for the inlay, and should be cut as deep as the safety of the pulp will permit. The surrounding walls bear an angular relation to the axial, and are almost parallel, with a slight labial inclination. This is the very best form that can be given the cavity, and, if followed, provides sufficient anchorage for the retention of the inlay against the usual forces that may act upon it for its displacement. The slight labial inclination of the walls allows of the removal of the matrix without

[1] Johnson's "Operative Dentistry."

distortion, and also gives the strongest margin to t
inlay.

Fig. 37 illustrates a labial cavity in an incisor. F
38 is a section of the same cavity. The margins of t
cavity have been extended to the angles, and the su
rounding walls are almost parallel. The cross secti
shows the axial wall flat, providing a suitable seat up
which the inlay rests.

CHAPTER VIII

CONSTRUCTION OF THE PORCELAIN INLAY

It is quite evident that in order to produce a good inlay not only must the cavity and margins be properly prepared, but the impression of that cavity must be accurately secured if a well-fitting inlay is to be made. The matrix form is made in either gold or platinum, depending upon the use of either the low or high fusing body. With the advent of the electric furnace, and the ease with which platinum may be annealed, the high fusing body has grown in favor. For a time considerable discussion was maintained concerning the respective advantages of the different bodies, based more upon the virtues of the matrix material than upon the advantage of one kind of body over the other. The ease of adaptation to the walls of the cavity gained in the use of gold appeared as a very effective argument in its favor. Furthermore, it was stated by the gold advocates that the toughness of platinum precluded an exact impression of the cavity with this material. With the perfection of the electric furnace, however, this argument could not be sustained. It was found that the toughness of platinum could be considerably lessened by subjecting it to a high heat in the muffle, and that in its annealed state a very satisfactory impression of the cavity could be formed, while its greater resistance enabled one to secure the cavity form without an

equal risk of tearing the material, as obtains when gold used. The thickness of the platinum used in making t cavity form is .001 of an inch, and a piece sufficient large is used to enable the operator to hold the ends ov the surface of the tooth beyond the cavity margins. labial cavities the preparation of the matrix is quite simple matter, and the material may be cut large enoug to allow of easy handling; but in proximal and proximo occlusal cavities the arrangement is somewhat different In these cases it is necessary to trim the material quit close to the marginal outlines, to prevent its interlocking in the act of removal. This should be cautiously performed, otherwise it will be found that too much material has been cut away. This is most likely to occur at the gingival margin; therefore, it is safer to allow of a considerable overlap in this region, in the first place; later this can be removed by degrees, as the material is adapted to the cavity.

Many instruments have been designed to aid in adapting the matrix material to the walls of the cavity. Most operators quickly learn to depend upon a few forms, which usually suffice for almost all cases. Two or three of the amalgam instruments and a piece of spunk, or a moistened pledget of cotton, will answer in nearly all cases, and have been the means with the writers of forming the matrix almost exclusive of the aid of any other form of instrument, the moistened pledget of cotton proving as efficacious as either spunk or camphor, both of which are held in high repute by many porcelain workers. Instruments with rubber tips made in different sizes will also be found valuable. When the matrix material has been thoroughly adapted the moistened cotton or spunk is lifted from the cavity and the matrix very carefully removed. The camphor, the suggestion

of Dr. Allen of Kansas City, remains in the matrix, and is an aid in preventing possible alteration of form of the matrix in withdrawing it from the cavity; it is then placed in alcohol, which dissolves the camphor, and afterward passed through an alcohol flame, which completely burns out the camphor, leaving no residue.

In proximal cavities the difficulties under which the matrix is formed are much greater, and much experience is required before they are finally mastered. Sufficient working space is of first importance, and must be secured through separation, if a good inlay is to be made. In adapting the platinum to the cavity, it is necessary to bear in mind that considerable overlap must be formed in the gingival region; otherwise it will be found, as the material is forced into the cavity, that the insufficient size of the material will fail to give an exact outline of the gingival region. The labial and lingual portion of the metal will have to be cut quite close, as previously noted, in order to enable the operator to remove the matrix without distortion.

Having perfectly secured the outlines of the cavity, the matrix is carefully removed and ready to receive the porcelain body. The proper shade is selected, and mixed, preferably with *distilled* water—alcohol may be used—and the paste prepared with either water or alcohol is applied to the matrix by means of a fine pointed brush. The brush may be moistened in water and turned to a fine point upon the glass slab by rotating the handle between the fingers. The point of the brush will then lift a portion of the body which is added to that in the matrix. This is repeated until a minimum degree of moisture is retained in the porcelain body. This is placed before the opening leading to the muffle, the heat of which will quickly remove all remaining

moisture. Care should be taken that the too quick evaporation of the moisture does not loosen the porcelain body from the matrix.

The inlay is now ready for the first baking. This should be carried only to the point which yields a "*biscuit bake,*" that is, the body in a vitrified state without gloss. To carry the fusing at this stage beyond this point, in view of the necessary bakes to be made before the inlay is completed, would finally result in an alteration of the shade, as well as the quality, of the porcelain. It is almost impossible to give such directions as will enable the inexperienced in the beginning to gain satisfactory results. Every worker must pass through the school of personal experience before he gains confidence in his ability to comprehend the degrees of heat, as revealed by the "heat color" of the furnace, and to know just how long the bake should be allowed to go on to secure certain results. The introduction of the pyrometer has proved of value in relation to the fusing of porcelain, but its value is not as positive as the experience gained by the worker who has trained his eye to read the heat of the furnace, as revealed by the color of the muffle, and who can regulate to a nicety the time required to yield a "*biscuit bake,*" or a complete fusion.

Having made the first, or biscuit bake, the inlay is withdrawn from the muffle; it will then be seen that the contraction of the body has drawn it away from the matrix, or that crevices have formed in other parts. In large inlays the contraction of the porcelain compound may alter the form of the matrix. To obviate this it has been recommended to invest the matrix, but this presents disadvantages to the formation of the inlay without positively correcting the condition for which it is recommended. The invested matrix cannot be retried

in the cavity to determine if any change of form has taken place in the baking; neither can it be placed in position for observation as to proper contour, while in the process of construction. These disadvantages have induced the general abandonment of this method of constructing the inlay, especially as it was found not to positively inhibit slight changes of form, owing to contraction in the investment material.

The crevices formed by the first bake are filled in with the porcelain body, the inlay built out to conform to the contour, thoroughly dried, and again placed in the muffle. In small inlays the second bake may be sufficient to complete the inlay, so that the fusion may be carried to the point that will yield the enamel effect. Large inlays, as a rule, will require one or more additional bakes prior to completion, so that care should be exercised that the final bake alone gives the enamel or gloss fusion.

Having given the inlay its final bake, it is slowly cooled, stripped of the matrix metal, and prepared to be permanently retained in place. Nothing that can be done toward this end is of equal value to the proper preparation of the cavity. If the cavity has been formed upon correct lines, the roughening of the inner side of the inlay alone is necessary for permanent retention. Grooves may be cut in the inlay by means of a small diamond disk, or the surface may be etched with hydrofluoric acid. The grooves should be cut only if they do not weaken the inlay, in which state it is more likely to fracture. If the acid is used the inlay must be set in wax, so as to expose that portion alone intended for the action of the acid. The acid is usually allowed to remain from five to eight minutes, after which it is washed off with water, and the inlay subjected to an alcohol

bath. This detaches a layer of porcelain, which is removed, and exposes a roughened surface to which the cement very strongly attaches itself. This attachment may be strong enough to resist force that will fracture the inlay. The mouth should now be effectively napkined so as to insure dryness, which in nearly all cases can be secured without the use of the dam. The cement is mixed to a creamy consistency, a portion of which is applied to the inner surface of the inlay, also in the cavity, and the inlay is then pressed to place and held in its proper position until the cement hardens. In proximal cavities, after the inlay has been set, it is in contact with the adjoining tooth, no further precaution is necessary to prevent its displacement. Upon labial or buccal surfaces, or restorations of the incisal edge, or in very large restorations, floss silk, or tape, may be tied around the tooth, securely holding the inlay until the cement has thoroughly hardened.

The Esthetic Effect of the Inlay.—The principal recommendation of the porcelain inlay is the artistic effect attained when it has been so well matched to the color of the tooth as to defy detection at conversational distance. If this result has not been secured the operation is more or less of a failure. A badly matched porcelain inlay carries less recommendation than a good gold filling. The rules that govern the construction of an inlay that closely approximates the shade of the tooth in which it is placed, cannot be so explicitly written that the beginner, in this work, can follow them with unvarying success. The experienced porcelain worker finds at times the obstacles surrounding the color problem almost insurmountable, and frequently his most painstaking efforts are rewarded with unsatisfactory results.

The size and location of the inlay have a very important bearing upon the color. Almost all teeth present one shade at the gingival third, another at the middle third, and still another at the incisal third. An inlay located upon the labial or buccal surface, occupying the gingival third of the tooth, may be so well matched as to meet all esthetic requirements, whereas one extending into the middle third of the tooth may defy the most expert workers in porcelain. Inlays upon the proximal surfaces frequently, after setting, appear darker than the tooth. It is recommended to select porcelain a shade darker for inlays upon the labial or buccal surface, and for those upon the proximal surface a porcelain that is a shade lighter.

Furthermore, the cement is an important factor in the problem, one which at all times must be carefully considered, if good results are to be attained. This is particularly true in relation to small inlays. In large inlays the bulk of material may be utilized to advantage in offsetting the alteration which the cement usually effects in the color of the inlay.

Probably the very best rules to follow may be deduced from the work of Dr. W. T. Reeves, who has given much thought to the vexatious subject. He advises building the inlay in different layers of different enamel shades. This will break up the absorption and refraction of light rays, so that the inlay will appear almost of the shade, looked at from any angle. This also prevents, in a large degree, the reflection of the cement through the inlay. Most operators have had the discouraging experience of finding the inlay completely altered in appearance after setting, which, prior thereto, appeared so well matched to the color of the tooth as almost to defy detection. That the method of build-

ing the inlay in several layers of different colors of porcelain largely overcomes this can be easily demonstrated in practice. Another helpful factor in the color problem is the use of a *white* cement powder, excepting in those cases where the deep yellow or gray color of the tooth may be emphasized in the inlay by the use of a powder having a similar color.

CHAPTER IX

THE CONSTRUCTION OF THE GOLD INLAY

The gold inlay may be considered under two heads, the *matrix inlay* and the *cast inlay.*

THE MATRIX INLAY

The matrix inlay has been almost entirely supplanted by the cast inlay, as the results obtained by the latter system of filling cavities are far superior to those obtained by the former. However, in exceptional cases the matrix inlay may be utilized to advantage. In shallow buccal cavities of molars where an excessive hypersensitivity of the dentin, such as is occasionally found in these locations, precludes the preparation of the cavity so that a satisfactory wax model can be made, and where the patient is unwilling to submit to a general anesthetic, in order to secure the necessary preparation of the cavity, this class of cases may be filled with a matrix inlay with very satisfactory results.

Molars with excessive loss of tooth substance, and where it is deemed hazardous, owing to the proximity of the pulp, to prepare a foundation for the seating of a cast inlay, may be prepared by drilling four pits, mesial, distal, buccal, and lingual, for the reception of 18 or 20 gage iridio-platinum pins, by means of which a matrix inlay may be securely held in place, and then built up with solder to open the bite the desired distance. To prepare the cast inlay, held in position by

means of pins as described above, is almost impossible as the patient in biting down upon the wax leaves but a very thin layer insufficient for its accurate removal with the pins in position. In fact, if it is desired to attach pins to cast inlays, they must penetrate into the inlay for a considerable distance, otherwise the union is insecure. If these difficulties could be effaced, still it would be as easy, if not easier, in these cases to prepare the matrix inlay, for which fact, if no other, a brief consideration of the system may not be out of place.

Dr. C. L. Alexander,[1] in 1896, presented before the Southern Dental Association a paper describing his method of making large restorations and utilizing the matrix with posts as abutments for bridges. Dr. Alexander uses platinum foil of about 40 gage; this is adapted to the walls of the cavity, or the surface to be restored. The plate is perforated by an iridio-platinum post and made to enter the pulp canal, which is previously prepared; an impression is taken of the plate with the post in position, invested, and the post soldered to the plate with pure gold. The plate and post are now returned to the tooth and carefully reburnished. An impression is next taken, and, when an occlusion is required, the patient is instructed to bite into the impression material prior to its hardening. Each side of the impression is filled with any of the ordinary investment materials and mounted upon an articulator. Removing the impression material the contour of the tooth to be restored is built up in wax; over this thin platinum plate is carefully burnished covering all the wax excepting at one wall. The work is cut away from the model and invested, with the exception of that part of the wax left

[1] *Dental Cosmos.*

uncovered by the platinum. Through this opening the wax is boiled out and later 22-k. gold solder or pure gold flowed in. Fig. 39 illustrates the various steps of the

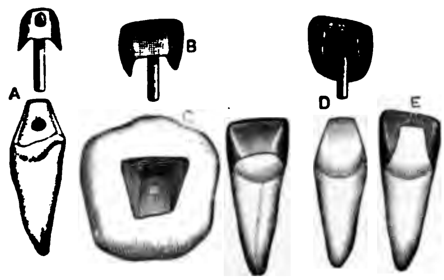

Fig. 39.

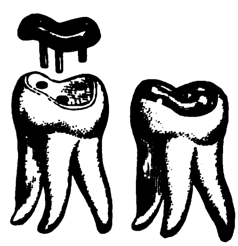

Fig. 40.

process. Fig. 40 shows a molar with an occlusal restoration.

To prepare a wax model for a cast inlay would necessitate cutting away sufficient tooth substance to give a working bulk to the wax. In many cases this is not only difficult, but impossible, as previously noted; in others, it might lead to a pulp proximity that might endanger its vitality. With the matrix system two, three, or four spots are selected on the surface of the tooth to be restored, which are not excessively sensitive, and which, when drilled for the reception of the posts, will not approach too closely the pulp, the inlay is then constructed as previously described.

Dr. Alexander[1] now constructs his inlays in the following manner: A piece of Alexander's plastic inlay gold[2] of sufficient size is molded with the fingers to conform to the shape of the cavity to be filled; this is pressed to place, removed and invested in sump, leaving only a

[1] *Cosmos*, 1909.

[2] Alexander's special inlay gold is a pure gold in a state of fine division incorporated with a binder so that the material can be easily manipulated. It is molded to fit the cavity accurately and the binder is burned out. The high grade solder fills up the interstices, making a solid inlay.

pinhead exposure, over which 22-k. solder is placed a fused, after the binder has been burned out. The he is applied from beneath, avoiding air pits. Special i struments and investment material are being manufa tured for this work. The method is much simpler tha casting, and through it perfectly fitting inlays may b constructed.

THE CAST INLAY

The credit for the development of the cast inlay as made at the present time belongs to Dr. W. H. Taggart. It is due to his genius that the problems attending its final evolution were solved, and although many apparatuses quickly followed the one introduced by Dr. Taggart, which apparently give highly satisfactory results, and which are much more simple in design than Dr. Taggart's, the credit for the perfection of the method belongs to him. That the present enthusiasm concerning the cast inlay may be somewhat subdued by subsequent developments must be allowed. Its exact place in operative procedures can only be determined after a sufficient test, the time for which has not as yet passed; but we know enough concerning it to recognize its great value, especially in large restorations in molars and bicuspids, and the valuable modifications it has wrought in crown and bridge work. Without recognition of the fact that permanent results with this method of filling cavities can be secured only after thorough mastery of all the details appertaining to it, and that the same degree, if not greater, of skill is necessary as in the use of other filling materials, failure will surely follow.

In making the filling the special wax is softened in water heated to about 140° F. Care must be exercised that the temperature of the water is not raised too high, otherwise the wax works pasty; insufficient heat of the

water induces the wax to crack, and is just as bad for the making of a good model. With little experience the correct heat can be determined by immersing the finger

FIG. 41.—DR. TAGGART'S AUTOMATIC WAX WARMER.

in the water. Dr. Taggart has now devised an electric wax heater, which heats the wax automatically until the proper degree of plasticity has been obtained (Fig. 41).

The softened wax is worked between the fingers, again softened by immersing it in the heated water, and forced into the cavity, which has been previously moistened with soap water, or some other substance which will allow of the easy withdrawal of the wax. The patient is now requested to bite into the wax. At this point the operator should examine the occlusion for its correctness, otherwise an inlay may be constructed with a faulty articulating surface.

If the occlusion is found to be correct, the wax is chilled with cold water, and with suitable instruments carved to the desired form. It is best to shave off thin sections of the wax until it is flush with the cavity margin. When the wax is trimmed down to the buccal and lingual cavity margins, a thin instrument is forced between the wax and the adjacent tooth, and the proximal and gingival portions are suitably trimmed. It sometimes occurs that too much wax is cut away, so that when the finished inlay is placed in the cavity it does not restore the proximal contact. In such cases a piece of 22-k. gold solder may be flowed over the proximal surface of the inlay, and more added, if necessary, to remedy the fault.

The wax model being formed, it is mounted on the sprue former, and ready for investment. *This should be done without delay.* From experiments recently conducted by Dr. E. Smreker, reported in the *Items of Interest* for 1910, it was apparently found to reduce the contraction of the inlay. A good wax is also an important factor in the final result. Dr. Taggart recommends a wax [1] that is sluggish in its movements, and which, at the temperature of the mouth, will break before it will bend. The investment material is mixed to a thin

[1] *Items of Interest*, July, 1911.

creamy consistency. Here, again, several factors must be observed, according to Dr. Taggart,[1] if satisfactory results are to be obtained. Dr. Taggart strongly insists upon definite proportions of water and powder, and has devised several instruments in order that uniform results may be secured (Fig. 42). The proportions of water and powder are secured by weighing, and by means of the automatic mixer definite results are always obtained. By means of a brush the investment mix is

FIG. 42.—DR. TAGGART'S AUTOMATIC INVESTMENT MIXER; ATTACHMENT TO LATHE.

carried over the surfaces of the model to cover it completely; the cup is next filled and the model carefully placed therein. The case is now set aside until the investment has hardened. When this has occurred the sprue former is removed and the process of burning out the wax is begun. Here, also, as in the previous steps of the procedure, Dr. Taggart emphasizes the importance of obtaining like results. He writes as follows:[2] "If

[1] *Items of Interest*, July, 1911.
[2] *Ibid.*

continuously duplicating conditions, as I have previou
outlined, is of any importance in scientific casting, it
equally so in the simple burning of the wax, and I ha
devised a burner for this purpose, and as it is done aut

FIG. 43.—DR. TAGGART'S WAX BURNER.

matically you can see what a time saver it is" (Fig. 43).

Considerable experimentation has been done to determine the shrinkage of gold cast in a mold, and the effects upon shrinkage when cast in a mold heated to red heat, or in a cooled mold. In the *Dental Digest* for July, 1909, Dr. Lane reports experiments which lead him to the

conclusion that the shrinkage of gold on cooling is somewhat neutralized if cast in a flask and investment heated to a red heat at the moment of casting. In the August issue of the *Cosmos,* 1910, Dr. C. S. Van Horn reports experiments confirming Dr. Lane's conclusions, and strongly argues for a hot mold in order to make the casting more nearly the size of the wax pattern. Previous to this Dr. Ward, *Cosmos,* September, 1909, concluded that the gold should be cast "into molds which have been heated sufficiently to eliminate mechanical moisture and allowed to cool till they can just be handled with the hands without discomfort, if we are to place the casting of gold on a practical as well as a scientific basis." Concerning these conclusions, Dr. Van Horn, in the paper previously referred to, writes as follows:

"And in view of the fact that Dr. Ward's deductions are based largely upon cast iron, the formula for which is not given, that he does not give us measurements, except by analogy, and that he does not explain why the rapid cooling of gold modifies the natural shrinkage, except to say that it is because of rapid cooling, we cannot consistently consider his remarks in connection with the shrinkage problem."

At the present state of our knowledge the argument appears to be in favor of the hot mold. A button of gold is melted and under pressure is forced into the mold. It is essential to have more than just sufficient gold to reproduce the wax pattern, in order that an exact casting may be made. When the casting has cooled, it is removed from the investment, all traces of which, as well as all surplus gold, should be removed and the inlay placed in the cavity, when the patient returns, to determine the accuracy of the fit. It may be found that the filling does not accurately go to place; this may be

due to excrescences of gold upon its inner surface, as the result of air bubbles, or the cracking of the investment. A small stone in the engine will remove these and, as a rule, allow the inlay to go to place. The final fitting and polishing should be done with the inlay in position, in order to secure closest adaptation of the inlay to the cavity margins.

The *Journal of The Allied Societies,* June, 1910, contains a description of the *impression method* of constructing gold inlays by Dr. H. W. Gillett. This method has found favor with many operators, who at first used the wax model. Dr. Gillett takes an impression of the cavity and adjoining tooth with the *Detroit Impression Compound,* which may be softened over the lamp. The impression is removed and invested in plaster, and when this has hardened, amalgam (copper) is packed into the impression, allowed to harden, and then separated from the impression; the amalgam die and occlusion previously taken are articulated. From this the wax model is prepared and the casting made, as previously described. While it is clear that this method, spoken of as the *indirect,* possesses advantages over the *direct,* it is also clear that the possibilities for introducing the element of error are multiplied. Nevertheless, excellent results may be obtained through it, as is attested by the number who now employ it in making the inlay, to the exclusion of the *direct* method previously employed by them.

CHAPTER X

HYPERSENSITIVE DENTIN

The term *hypersensitive dentin* is here used to indicate an abnormal responsiveness of the dentin, generally due to exposure, in distinction to that degree of sensation normal to the dentin.

The statement[1] "that in the normal condition dentin should be without sensation, and that the source of sensitive dentin, or of impressionable pulps, lies in their continued subjection to irritation by which responsiveness is developed" (Barrett), is likely to lead to confusion. *Normal dentin is not without sensation.* Its degree of sensitivity is not high, but nevertheless cannot correctly be considered in a negative sense. It is also inexact to entirely reduce the proposition of hypersensitive dentin to terms of exposure. While exposure unquestionably is the most potent and general factor in its development, a limited experience is sufficient, as a rule, to impress upon many operators that other factors exist that should not be overlooked in a consideration of this condition. Of these the most important is that high degree of perceptivity which usually characterizes the entire nervous apparatus in those temperaments classified as nervous, and which is reflected in the tubular contents of the dentin and renders that tissue acutely responsive when not exposed. It is in these cases of apparently inherent predisposition of the nervous system

[1] Johnson's "Operative Dentistry."

to pain that the dentist frequently encounters the greatest difficulty in reducing the high responsiveness of the dentin to a degree of tolerance necessary for the continuance of the preparation of the cavity, and not infrequently the entire list of local therapeutic measures may be exhausted without establishing the tolerant state, rendering recourse to general remedies imperative if a satisfactory operation is to be performed.

Diagnosis.—The exalted sensitivity of the dentin bears a marked correspondence to the pain of an irritated pulp, especially in the early stages of pathological involvement. This becomes quite evident when it is recognized that the sensation of the dentin is dependent upon the vitality of the pulp, and that the tubular fibrils are in direct contact with the formative organ. Both an irritated pulp and hypersensitive dentin respond to thermal, chemical, vital, and mechanical forms of irritation. Both give unlocalized impressions, as the tactile sense is not resident in the pulp, and both respond to anodyne applications. There is but one way in which the distinction as to which tissue is primarily irritated can be made out: In hypersensitive dentin the pain ceases immediately upon removal of the irritant. In pulp irritation the pain continues for seconds, or minutes, depending upon its state, after removal of the irritant.

Therapeutics.—The fact that so small a percentage of the populace receive dental treatment is in a very large degree due to a fearsomeness developed by the tales of infliction of those who have braved the so-called torture chamber. That many of these tales are gross exaggerations cannot be doubted; that they have been a retarding factor, preventing a great number from receiving dental attention, likewise cannot be doubted. More recently, since the vital importance of sound teeth as

a factor in the individual's health has received greater attention, an increasing number have been impressed with the necessity of conserving the dental organs. It is in this relation that the treatment of hypersensitive dentin is probably as important, if not more so, than any other procedure in dentistry, and may justly claim for its successful mastery a devotion to study not eclipsed by any other of the operative procedures. It is quite universally recognized that an essential requisite in the successful control of patients is to be found in a sympathetic attitude. A lack of this quality will accentuate the fear of the patient and tend to develop a high nervous perceptivity, in which slight sensations are exaggerated into painful ones. On the other hand, a sympathetic demeanor tends to allay undue nervous apprehension. It secures the confidence of the patient and establishes a sense of security not attainable in any other manner and far more effective as a therapeutic measure than other modes of treatment. This is the psychologic factor in the treatment of hypersensitive dentin that defies advantageous description. Each patient is a law unto himself in its application, and the discriminating judgment of the operator must be finely exercised so that its great value should not be lost either from overuse or non-use.

Having induced the calm submissiveness of the patient, the next step of importance is the recognition that in the use of sharp instruments and in the maintenance of dryness we have two adjunctive measures in the treatment of hypersensitive dentin not surpassed in value by any remedy known to the practitioner. In fact, many operators place almost their entire reliance in successfully combating this *bête noire* of dentistry in the use of sharp instruments, a dry cavity, and the confidence they

instill in the mind of the patient by their sympathetic attitude. Rarely, indeed, do the requirements call them outside of these therapeutic measures. Sharp instruments cut quickly and, therefore, less heat is developed in their use. The instrument should be drawn away from the pulp and not toward it. This diminishes the pressure; and as both heat and pressure result in painful impressions, the need for their avoidance is evident. The warm air has a drying effect upon the dentin, which reduces the conductivity of the tissue and tends to control pain.

If the use of these measures fails to establish the patient's tolerance for the necessary continuation of the preparation of the cavity, recourse must be had to other therapeutic agents. These may be classified for convenience as *anodynes, escharotics,* and *anesthetics.* The anodyne group comprises the essential oils, cloves, cinnamon, thyme, etc., also cocain, morphia, etc. The essential oils are most effective in deep-seated cavities applied after partial desiccation by blasts of warm air. A very effective application, at times, is thymol dissolved in alcohol. The alcohol quickly evaporates, cooling the dentin and apparently allowing the thymol to penetrate the tissue. Menthol dissolved in chloroform and ether in the following proportions acts similarly: Menthol, grs. xx; chloroform, xʒi; ether, x℥ss.

Morphia and veratria have little, if any, effect applied locally. Given internally one-half hour prior to the operation they sedate the central nervous system, diminishing local impressions. Gelsemium in 5-drop doses has also proved effective. But such practice should not be encouraged; it is attended by too many dangers. In patients with pronounced *hysterical* proclivities the need for the internal administration of drugs may arise. Very

excellent results may be had from the use of either valerianate of ammonia or asafetida, given in 5-grain doses one hour prior to the operation. These drugs are free from the objections that may be urged against the internal use of morphia.

The agent that probably has the most general use in the treatment of hypersensitive dentin is the hydrochlorate of cocain. Its well known property of paralyzing the sensory nerve terminals at once suggests its use in relation to the obtunding of dentinal hypersensitivity, but not until it is made to penetrate this tissue does it prove effective. This is accomplished in two ways: by the use of the *galvanic current* and by *pressure*. Cataphoresis has been before the profession for a sufficient time to make its extended treatment in a work of the present scope unnecessary. Its use has been quite generally, if not universally, abrogated, due to the time consumed in making the means effective, and to the special expensive apparatus necessary for the process. These objections are obviated, with no sacrifice of general effectiveness, by the use of the pressure method. A pledget of cotton saturated with a 2-10 per cent. solution (stronger solutions can be used) of the hydrochlorate of cocain is applied in the cavity; over this is placed a disk of gutta percha, or temporary stopping, and pressure applied, at first gentle, not to cause pain, after which it may be gradually increased. After one or two minutes it will be found that a degree of dentinal anesthesia has been induced which will enable the operator to make further excavation painlessly. This may be continued until satisfactory preparation of the cavity is reached.

The special instruments which have been introduced for the purpose of forcing the cocain solution into the

dentin should be used only when pulp removal is intended. The risk incurred by their use, of forcing the anesthetic into the pulp, is so great that it seems strange that the danger did not from the beginning impress itself upon the profession. This may have been due to the lack of recognition that cocain is a *protoplasmic poison,* and that its forceful entry into the tissue of the pulp will almost always result in pulp devitalization. In this sense it may also be well to emphasize the precaution that should be taken when the pressure is applied by means of an ordinary burnisher to the gutta percha covering, to be always mindful of a pulp proximity; otherwise this organ might be uncovered and complications arise that can with care be avoided. A number of tablets containing cocain, or some substitute, together with other agents, have been placed upon the market. The tablet made by Parke Davis & Co. after the formula of Dr. Hermann Prinz has proved very efficient in the writers' experience: Novocain, gr. 1/3; thymolated adren., gr. 1/1500; sodium chlorid, gr. 1/8.

In very shallow cavities, especially those situated at the gingival border, where the cocain pressure method cannot be successfully utilized, recourse must be had to the *escharotics.* These comprise such agents as phenol, silver nitrate, zinc chlorid, sulphuric acid, trichloracetic acid, hydrates of sodium and potassium, the latter used in combination with equal parts of phenol and known as Robinson's Remedy. The cavity should be under the rubber dam. This is at all times advisable, but especially so when it is intended to use the foregoing remedies. The dam affords protection to the surrounding tissues and insures the maintenance of dryness, a necessary factor for the effective action of these agents. If it should be found expedient to make use

of any of these remedies in deep-seated cavities, some means of protection must be afforded the pulp from their irritating impress. This is usually accomplished by placing a thin wafer of temporary stopping over the dentin overlying the pulp, or by placing two or three layers of an impervious varnish, such as cavatin or rubber varnish, in the same region. In spite of the precaution that may be taken, a painful response follows the use of many of these agents. This is especially to be noted in the use of zinc chlorid deliquesced. If the pain following the use of this remedy is very acute and lasting, the cavity should be irrigated with sterilized tepid water, dried, and followed by an application of oil of cloves, cinnamon, or camphophenique. Any of these agents will quickly allay the distressing symptom.

According to the testimony of some operators the refrigerants have proved to be remedies of value in the treatment of hypersensitive dentin. The group includes such drugs as ethylchlorid, rhigolene, ether, etc. They act as local anesthetics by abstracting the heat of the part to which they are applied. In the authors' experience they have not proved effective agents in dealing with this condition. To reduce the tissue to a condition of anesthesia, or even partial anesthesia, invariably results in a severe paroxysm of pain to which many pulps ultimately succumb. This has occurred with sufficient frequency, and the pain their use induced has been spoken of so complainingly by most patients, that these drugs have been almost entirely eliminated from the authors' practice. This applies with special force to the use of ethylchlorid sprayed against the dentin. Note has been made of the solution of menthol in chloroform and ether, or cocain dissolved in the above menstrua.

The evaporation of the chloroform and ether necessarily reduces the dentinal temperature, but these solutions act very helpfully and should not be confounded with the effect of the ethylchlorid spray. So, too, the dipping of the bur in ethylchlorid is useful in preventing the high heat at times developed by the rapidly revolving bur, and in this sense is a therapeutic factor of value.

If the various means previously considered fail to relieve the hypersensitive condition, the use of a general anesthetic remains to be noted. The objections to their use, especially *chloroform* and *ether*, are many, and so well sustained that the practice of their utilization has few followers. In the writers' opinion this does not apply to the use of nitrous oxid. The absolute safety of this agent as an anesthetic, which its record of over half a century fully sustains, in itself sets a line of demarcation that cannot be successfully denied. Ether, not being nearly so dangerous an anesthetic as chloroform, may be used, but it should not be given to affect the patient beyond the *conscious state*. Dr. Jack[1] thinks very favorably of its use when all other means have failed to alleviate the dentinal hypersensitivity. But he recommends the induction only of the first stage of anesthesia wherein consciousness still remains. Chloroform the same author positively interdicts in the treatment of the condition under discussion. With this all operators who are fully conversant with the history of chloroform in its use for dental operations, and with its physiological action, will fully concur. Furthermore, it must be noted that once the patient is impressed with the value of this mode of obtunding hypersensitive dentin, subsequent attempts at cavity preparation become

[1] "American Textbook of Operative Dentistry."

an impossible procedure, unless the same means are utilized. This actually means that at every sitting the patient, once given an anesthetic, will insist upon again being placed under its influence, thus establishing a condition fraught with serious consequences from all points of view.

Reference has been made to the safety of nitrous oxid. This is generally conceded. Therefore, its use as a therapeutic means for the relief of dentinal hypersensitivity is good practice when utilized as a *dernier ressort;* that is, after all local means fail. The anesthesia is quite sufficient for the preparation of most cavities, and, aside from the general objection alluded to, and which applies to the use of all anesthetics as a means of overcoming dentinal hypersensitivity, nitrous oxid is free from all other unfavorable consequences.

Recently Dr. G. T. Gregg of Pittsburgh has introduced a special form of inhaler whereby nitrous oxid and oxygen can be administered to induce a state of analgesia entirely sufficient for the painless excavation of cavities, without total loss of consciousness. The inhaler is adjusted to the patient's head, in no way interfering with the preparation of the cavity.

CHAPTER XI

EROSION

Definition and Etiology.—Erosion is a dental lesion characterized by cup-like excavations, which can be accounted for only if we admit the existence of both chemical and mechanical factors. Alone, neither is competent to produce the smooth and polished areas truly characteristic of the condition.

The term *erosion* is, at times, employed to indicate a variety of enamel lesions resultant of hereditary syphilis, the well known type of deformity known as Hutchinson teeth, named after Jonathan Hutchinson of

A. B.

FIG. 44.—SYPHILITIC TEETH.

A. Recently erupted. B. At maturity. (Burchard's "Pathology.")

England, who first adequately described the condition (Fig. 44).

More recently the term *dental erosion*[1] has been employed to apply to the form of enamel defects due to hereditary syphilis, in distinction to *chemical erosion* found as above described, in which we have a loss of tooth substance due to the action of an acid, and further

[1] *Dental Cosmos*, December, 1909.

distinguished by the polished areas which can only be conceived as being formed in a mechanical manner.

The term *dental erosion* as applied to the syphilitic manifestations of enamel defects is not well chosen, and its use is likely to lead to considerable confusion. The *chemical erosion* under present consideration is a distinctive condition appearing most frequently upon the labial surfaces of the anterior teeth, although the bicuspids and molars may be affected. It is entirely distinct from caries, which occurs most frequently in pits and fissures, and adjacent to the contact point of teeth; in other words, where lactic acid fermentation takes place and goes on undisturbed. In chemical erosion the cavity begins where fermentation is least likely to occur. Furthermore, in caries we find softened dentin, usually discolored. In erosion these characters are absent, although caries may be inaugurated in an excavation of erosion. Erosion is also distinct from *abrasion*, a mechanical wearing away of tooth substance, usually noted upon the occlusal surfaces of teeth.

Erosion has been reported as existing in individuals who had never made use of the tooth brush. Tomes also reports its appearance in animals. In these instances the passage of the food and the friction of the lips and cheek must have been competent to establish the abrasive effects noted. In no other way can the existence of the smooth and polished areas be made out.

Areas of erosion are found most frequently upon the labial and buccal surfaces, especially the labial. These cases appear to be associated with an altered secretion of the labial glands. Dr. Kirk, in an address before the Second District Dental Society, to which we shall again refer, calls attention to a condition of *general erosion* which may attack any of the surfaces of

teeth, and which he believes to be due to excessive oral fermentation resulting in the formation of large quantities of *lactic acid.* Dr. Hinkins,[1] in a study of erosion, reports that acetic, formic, propionic, and butyric acid, any of which may result from oral fermentation, are also competent to produce the same effect as lactic acid, and the crystals formed by the combination of any of these acids with the calcium constituents of the tooth could not be differentiated by means of the micropolariscope.

From a series of investigations conducted by the late Dr. W. D. Miller, reported in the *Dental Cosmos,* the condition appeared to this investigator as being due to the mechanical action of powders and other substances used in the cleansing of the teeth. But, notwithstanding the high authority of this experimenter, the condition cannot be considered, in view of the available data, in an etiological sense, apart from a chemical agent having the power to combine chemically with the substance of the tooth, and either formed in the mouth or else discharged by the mucous glands of the lip.

In a large percentage of cases of erosion the coexistence of a condition commonly designated the "*gouty diathesis*" can be clearly established, and, as the gouty diathesis essentially implies a nutritive disturbance, under a state of suboxidation, in which neutral or alkaline secretions are changed to an acid reaction, support is given to the theory of the systemic causation of the disease.

Dr. A. P. Brubaker, in the *International Dental Journal,* December, 1894, presented an article on "The Causation of Dental Erosion," in which he sought to ac-

[1] *Items of Interest,* March, 1907.

count for the origin of the acid in the following manner: The gouty diathesis essentially implies the retention of excessive waste in the blood; this results in an irritation of various cells throughout the body. In relation to secreting cells this irritation would lead to an altered activity of these cells with an alteration in their secretion. The physiological law of secretion as it occurs in mucous glands is that the cells of the gland draw from the blood such materials as they transform into mucin. Upon the amount of blood carried to the cells the production of mucin is dependent. During glandular activity, excited by the secretory nerves, the blood vessels are enlarged, owing to the action of the vasomotor nerves. This results in secretion. The nerves which affect the blood vessels and glands originate in special centers in the medulla oblongata. These centers may be stimulated in two ways: Irritation at the periphery and transmitted through sensory nerves, and second, by the character of the plasma carried to these centers. The condition characterized as the "*gouty diathesis*" is not only competent to bring about an increased blood supply to the glands, but if it persists leads to a permanent dilatation of the blood vessels supplying the glands. The plasma diffusing through the glandular cells normally contains the alkaline sodium phosphate. This salt readily parts with one atom of sodium when brought into relation with carbonic acid and leads to the formation of the acid sodium phosphate: $Na_2\ HPO_4+H_2\ CO_3=Na\ H_2\ PO_4+Na\ H\ CO_3$.

Under normal conditions the CO_2 formed during cell activity is insufficient to bring about the change of the alkaline sodium phosphate into the acid sodium phosphate. But with the increased cell activity brought about as noted, or with any condition which favors ex-

cessive retention of carbon dioxid in the blood, where it combines with a molecule of water and exists as carbonic acid $H_2\ CO_3$, the change of the alkaline into the acid sodium phosphate may occur.

Concerning this agent, Dr. Brubaker says: "The presence of this acid, it must be confessed, has not been demonstrated, inasmuch as there are no known tests by which it can be detected when dealing with such small amounts." However, granting its formation, is it competent to decalcify tooth structure? To determine this Dr. Brubaker immersed a tooth for a week in a weak solution of acid sodium phosphate. "At the end of a week the tooth showed two small eroded spots and a number of transverse furrows, due to the action of a tooth brush which was used daily. In addition the cutting edges of the tooth show a distinctly eroded character."

This would occur after the following manner: $Na_2\ H_2\ PO_4 + Ca_3\ (PO_4)_2 = NaCaPO_4 + {}_2H\ Ca\ PO_4$ (acid sodium phosphate + calcium phosphate = sodium calcium phosphate+acid calcic phosphate).

A double decomposition takes place—sodium calcium phosphate, an insoluble body, and acid calcium phosphate are formed. With the addition of a new molecule of acid sodium phosphate from the gland, a further reaction occurs: $Na\ H_2\ PO_4 + 2Ca\ H\ PO_4 = Na\ Ca\ PO_4 + Ca\ (H_2\ PO_4)_2$ (acid sodium phosphate+acid calcic phosphate=sodium calcium phosphate+diacid calcic phosphate).

"In this way the calcium phosphate of the tooth is disintegrated by being converted, first, into mono, and, second, into diacid calcic, phosphate."

In an address[1] delivered before the Second District

[1] *Items of Interest,* March, 1902.

Dental Society on "The Clinical and Chemical Study of a Case of Dental Erosion," Dr. Kirk apparently agrees with Dr. Brubaker as to the chemical reaction which results in the formation of acid sodium phosphate, as shown by the following: "The excess of carbonic acid in the blood is, to a certain extent, taken care of in the excretory cells of the kidney by the mass action of carbonic acid upon the sodium phosphate of the blood, thus: $H_2 CO_3 + H Na_2 PO_4 = H Na CO_3 + H_2 Na PO_4$." Again Dr. Kirk says: "Where through faulty metabolism carbonic acid is produced out of normal proportion, as in the gouty diathesis, then not only the kidneys but also the buccal glands take up this same action, and we have the conversion of disodium phosphate into the acid sodium phosphate in those glands, their exudate slowly eroding the teeth." As Dr. Kirk[1] at one time doubted the correctness of the above chemical reaction, closer study apparently has convinced him that it actually takes place, and this is in accord with the views of chemists who have studied the physiological and pathological reactions of the body.

In Dr. Kirk's studies of a case of dental erosion, incorporated in the address previously referred to, he suggests a classification of this condition into *general* and *local erosion,* according to its etiological relation. By dialyzing the saliva of the subject whom Dr. Kirk had under observation, he found by the aid of the micropolariscope crystallizable salts to have been contained therein, and, as Dr. Kirk believed, could only have been formed by the action of *lactic acid* upon the calcified constituents of the tooth, and, as lactic acid cannot be considered as being exuded by the human glands, its presence in the oral cavity must be ascribed to a condi-

[1] Burchard's "Pathology."

tion favoring excessive fermentation and production. In these cases any surface of the tooth may be attacked. For this condition Dr. Kirk suggested the term *general erosion,* in distinction of the local *erosion* caused by an acid mucus secretion of the glands, chiefly located beneath the lip, which usually attacks the labial surfaces of the anterior teeth, and which is due either to the acid sodium phosphate or the acid calcium phosphate.

In the investigations[1] reported by Dr. J. E. Hinkins, previously referred to, emphatic objections are sustained to the conclusions presented by Dr. Kirk. These objections bear upon the claim, made by Dr. Kirk in his address, that the micropolariscope determined the salts obtained from the dialyzed saliva to be calcium lactophosphate, calcium lactate, and magnesium lactophosphate—i. e., the salts formed by the action of lactic acid upon the inorganic constituents of the tooth. But Dr. Hinkins contends that, as acetic, formic, propionic, and butyric acid, any of which may be formed in the mouth by the process of fermentation, may also combine with the inorganic constituents of the tooth, and as the resultant crystals examined under the micropolariscope in many instances would have a similar appearance to those formed by the action of lactic acid, and as Dr. Kirk employed no *chemical tests* to support his finding of what he believed to be certain crystals, therefore Dr. Kirk's conclusions concerning the crystals which he obtained from the saliva of the case under study, and which he believed to be formed by the action of *lactic acid* upon the tooth structure, have not been scientifically made out.

Dr. Hinkins furthermore reports examinations of the

[1] *Dental Review*, April, 1906; *Items of Interest*, March, 1907.

salts obtained from the saliva of individuals suffering from general erosion, as follows: "In every case examined the crystals obtained from the dialyzed acid saliva were entirely different from those described by Dr. Kirk, and different from the sheaf-like forms which are obtained by treating calcium phosphate with lactic acid and allowing this solution to evaporate on slides, and which were, of course, the *so-called* calcium lactophosphate."

In further corroboration of the negative finding of lactic acid in acid salivas of individuals suffering from erosion, Dr. Hinkins states that the committee, of which he was a member, tested for lactic acid by chemical means. In six cases tested, only one showed lactic acid by Ewald's test, and this in amount far less than the amount of *acid* present in these cases as determined by *titration*. The report further claims that "the so-called calcium lactophosphate of Dr. Kirk is nothing but *calcium acid lactate,* that is, calcium acid lactate mixed with a small amount of calcium phosphate. *There is no phosphate radical in these sheaf-like crystals.* However, the compound of calcium acid lactate and calcium phosphate may have been broken up, as Dr. Kirk[1] claims, in the boiling of the solution.

Dr. Hinkins is as strongly opposed to the theory of *local erosion* as being due either to the formation of the acid sodium phosphate or the acid calcium phosphate, as intimated first by Brubaker and later supported by Kirk, as he is opposed to the theory of *general erosion.* His opposition is based on the claim that carbonic acid cannot convert hydrogen disodium phosphate into dihydrogen sodium phosphate. But in relation to this claim he is in antagonism to the prevalent

[1] *Items of Interest,* May, 1907.

view held by physiological chemists in regard to the acidity of the urine, the cause of which has been determined as being due to the presence of the acid sodium phosphate, which is dihydrogen sodium phosphate.

From investigations referred to by Dr. G. W. Cook several interesting facts may be gathered, all of which tend to demonstrate that the process of dental *erosion* cannot be considered as being a simple chemico-biological affection, the result, in all instances, of one agent, but that most likely many factors are concerned in the condition, some of which, at least up to the present time, have defied detection. Dr. Cook states that at one time he was of the opinion, as a result of his investigations, that *mucic acid* would produce a typical condition of erosion, but he soon discovered that many of the bacteria that ordinarily inhabit the oral cavity had the power to break up this acid; also that this acid quickly lost its solvent effect upon the tooth by being neutralized by the neutral salts which it extracted from the tooth, and that, while the saliva might contain certain mucoid substances from which mucic acid might easily arise, its quick neutralization and decomposition leave it undetermined as to the part this acid plays in erosion.

Reference is also made to the investigations of Acree and Hinkins, which appeared to show that at times the saliva taken direct from the salivary glands may contain as much acid as that detected in the mouth subject to fermentative changes; also that certain cells are quite readily affected in a manner that gives rise to the production of an acid. This has been noted by Brubaker and others. An interesting fact, developed from the work of these several investigators, disclosed the

[1] Johnson's "Operative Dentistry."

absence of lactic acid in the oral cavity of those affected with erosion, and of many suffering from caries.

In view of this, and of the uncertainty of the tests made by Dr. Kirk concerning the case he investigated, and which he believed to be caused by an over-production of lactic acid in the oral cavity, the part, if any, that this acid may have in causing *erosion* is not known. But the views of most investigators concerning the etiology of erosion appear to be that it is associated with an acid secretion of the mucus glands of the lip, and, while the nature of the acid or acids remains undetermined, the work of Brubaker, and later that of Kirk, concerning the origin and effect of the acid sodium phosphate, appear to offer the best working hypothesis in our comprehension of the pathological lesion known as local erosion.

Therapeutics.—In view of the available data concerning the etiology of erosion, its treatment may be considered under two heads, *local* and *general.*

Local Treatment.—The local treatment consists of the proper preparation of the eroded areas and the insertion of porcelain inlays, and the use of such therapeutic agents as might prevent, or else change, the nature of the glandular secretion.

Dr. Brubaker [1] recommended the use of the electro-cautery as a means of destroying the labial glands and thus preventing a possible perverted secretion from acting upon the tooth structure.

Dr. Geo. W. Cook [2] reports considerable success in the use of silver nitrate, especially in the first stages of the disease. At first he believed its beneficial effects to be due to its application to the eroded surface, but

[1] *International Dental Journal,* 1894.
[2] Johnson's "Operative Dentistry."

later he concluded that the results obtained were d
to the contact of the silver salt with the mucus glan
and in this way changing the character of the secreti
so as to prevent its deleterious action. But it appea
as though the good effects to be noted following the u
of silver nitrate might be due to its astringent actio
upon the gland, and not to its chemical tendency t
change the nature of the glandular secretion. Brubake
has shown the probability of the existence of an increased blood supply in glands giving off an altered secretion, which increased blood supply might be reduced to a state of normality by the astringent effect of silver nitrate, inducing a normal secretion.

The general use of porcelain as a filling in this class of cases marks a decisively progressive step in dentistry; in no other manner can the normal appearance of the teeth be as closely approximated, nor can as permanent an operation be made with any other material at our command at the present time. Before the advent of the porcelain inlay many operators regarded gold as a filling material in these cases as being contraindicated, not only because of its conspicuousness and consequent offense to the esthetic sense, but also because of its high negative potential position and the positive potential relation of the tooth favoring an *increased formation of acids,* and thereby aiding in the destructive effect upon the tooth.

With the filling of the eroded areas the patient is to be instructed in the probable value of the use of antacid agents as a means of neutralizing the acid secretions. Milk of magnesia, which is the hydrate suspended in water, serves this purpose admirably. A preparation has recently been placed upon the market to which have been added thymol, menthol, and flavoring

oils, the presence of these ingredients imparting other desirable effects to the mixture. It is to be used prior to retiring at night. It remains adherent to the surfaces of the teeth, and, as the destructive effect of the acid secretion is greatest during the period of sleep, the use of this agent at the time suggested is likely to prove most beneficial. Calcium carbonate, packed between the teeth and rubbed over the labial surfaces, is also an excellent remedy.

General Treatment.—The general concurrence of views of most writers concerning the etiology of erosion as being due to an acid secretion of the labial glands has been noted. And as the perverted labial secretion, in the light of our present knowledge, can only be regarded as expressing a departure from the normal equilibrium expressed as health, the applied therapeutics cannot be considered as being complete without a search being made for the discovery of the systemic factor that might be involved. It has been pointed out that the excessive retention in the blood of carbon dioxid, expressive of a state of suboxidation and related to a group of phenomena known as the "gouty diathesis," best accounts for the abnormal acid secretion. It might be, as intimated by Dr. W. X. Sudduth,[1] that a lowered nervous condition is responsible for the acid formation. The plan of treatment should include an attempt to deal with the systemic factor. Those cases [2] in which antigout treatment has been applied have responded favorably; so, too, with patients who developed erosion during an attack of neurasthenia, and in whom the disease appeared permanently arrested upon recovery from the nervous attack. It may be that the sys-

[1] Johnson's "Operative Dentistry."
[2] Burchard's "Pathology."

temic factor, owing to our limited knowledge, remai unknown. In such cases no permanent abatement the destructive action of the acid can be secured, unle the systemic factor in some unknown manner is fort nately eliminated. But the advances made in the stud of the saliva, and the additions that are being constantl made to our knowledge in pathological studies, offer basis for the hope that we are nearing the complete solu tion of erosion.

CHAPTER XII

PYORRHEA ALVEOLARIS

Definition.—The term *pyorrhea alveolaris* is used to indicate a disease marked by degenerative and necrotic changes in the alveolar and pericemental tissues, an increasing looseness of the tooth, tumefaction of the gum, a flow of pus from the alveolus, and, generally, deposits of calculi upon the roots of the affected teeth. The term pyorrhea alveolaris indicates but one symptom of the disease, i. e., a flow of pus from the alveolus, but the disease usually embraces all of the aforementioned conditions.

Almost numberless attempts have been made to introduce terms more descriptive of the pathological features of the disease, but not any appear to be used as extensively as the term *pyorrhea alveolaris,* which, perhaps, from long usage, appears to have a permanent hold upon the profession.

Dr. Peirce[1] gives the following list of synonyms: "Suppurative conjointe; pyorrhea interalveoli dentaire; gingivitis expulsiva; osteo-periostiti-alveolo dentaire; pyorrhea alveolo; cemento periostitis; infectioso-alveolitis; calcic inflammation; phagedenic-pericementitis; Riggs' disease; hematogenic calcic pericementitis; blenorrhea alveolaris; gouty pericementitis. To this list may be added the term *interstitial gingivitis,* introduced by Dr. Talbot.

[1] "American Textbook of Operative Dentistry."

Etiology.—Almost from the beginning of the recog-nition of the disorder antagonistic views have been held by observers as to its etiology. In 1875, Dr. John W. Riggs, in a paper before the American Academy of Dental Surgery, contended that the disease is of local origin, due to calcific deposits, and that the removal of these deposits almost invariably leads to a cure. These conclusions were in direct antagonism to the views previously presented by Dr. E. Magitot, who maintained that the disease was due to systemic factors. He recognized its frequent appearance in those of the rheumatic type. Both investigators regarded the thorough removal of all deposits as an essential feature of the treatment. In this regard there is at the present time a general unanimity. For the past thirty-five years, or more, these respective views as to the etiology of pyorrhea have been steadfastly maintained by the followers of these early investigators, and to-day the condition of the controversy is about the same—with probably a steady augmentation of number of those who contend that the clinical features grouped as pyorrhea, in some instances, belong to a class the etiology of which unquestionably is to be found in abnormal conditions of nutrition and metabolic changes, just as Magitot contended over forty years ago.

The followers of Riggs, on the other hand, insist that all clinical manifestations of pyorrhea alveolaris are entirely due to causes operating through the oral cavity, and with the thorough removal of these causes a permanent cure may be established in almost every instance. Each party to the discussion appears to be well fortified with records and patients. It cannot be denied that many patients can be shown who stand as conclusive testimony to the excellent results obtained entirely

by local means. The labors of such men as Drs. D. D. Smith, Robert Good, J. D. Patterson, and others who stand unalterably committed to the view that pyorrhea alveolaris is the result only of local causes, and who depend entirely upon local measures in treatment, show most satisfactory results.

On the other hand, reference has been made to the observation of Magitot that the disease appeared most frequently in the gouty and rheumatic. Dr. W. J. Reese,[1] in 1886, read a paper entitled "Uremia and Its Effect upon the Teeth," in which he stated that uric acid deposited from the blood caused inflammation followed by suppuration of the pericementum. In a series of investigations reported in the *International Dental Journal* for 1892-94-95, Dr. C. N. Peirce has conclusively demonstrated that, in certain forms of pyorrhea, called by him *hematogenic calcic pericementitis,* and later designated by Dr. E. T. Darby *gouty pericementitis,* the disease is "but a local expression of the gouty diathesis and directly dependent on the deposition of the uric acid, urates, and calcium salts in the pericemental membrane." In these investigations all the well known tests for uric acid were made, and each test revealed crystals of uric acid, sodium urate, and calcium phosphate, and seemed to establish beyond doubt that, in the form of pyorrhea alveolaris referred to, the cause was due to these deposits. These tests were made in connection with clinical observations, which of themselves strongly hinted the conclusion that the pyorrhea referred to was a gouty manifestation. Having incontrovertibly demonstrated the presence of the uratic salts upon the roots of teeth, it is a very easy matter to account for the subsequent pathological features. The salts by their pres-

[1] "American Textbook of Operative Dentistry."

ence induce first hyperemic and later inflammatory changes, thereby establishing a condition which offers little or no resistance to pyogenic infection. The pus becomes an additional factor of the degenerative and necrotic changes affecting the pericementum and alveolar walls. The destruction of these tissues leads to the progressive loosening of the tooth, until its loss puts to an end the disease process.

If the patient should apply for treatment at almost any stage of the disease, and the removal of all deposits should be effectively performed, and if, with this, and the use of germicidal agents and such other remedies as may induce the resolution of inflamed tissues the tooth should return to a condition of comparative normality, the argument of local causation of the disease, because local measures apparently effected a cure, would be extremely fallacious. Nevertheless, this appears to form a strong feature of the basis of the argument of those who contend that no systemic factor is involved at any time in pyorrhea alveolaris.

On another point of the discussion, Dr. J. D. Patterson[1] writes as follows: "Whatever the predisposition found in heredity and environment, yet without local irritation of some description the proliferation of cells found in hypertrophy does not ensue. If investigators in pathology tell us this, well may we put at once aside the claim often made that the condition under consideration (pyorrhea alveolaris) is *per se* of constitutional origin, or caused by a specific microörganism. Those who seek for the etiology of pyorrhea in obscure forces should return to the plain and provable logic of cause and effect, and forsake the speculative and unreliable. In the etiology of the condition the following statement

[1] Johnson's "Textbook of Operative Dentistry."

may be safely made: *Any irritant, of whatever nature, which impairs the integrity and continuity of the gingival gum margin, may cause pyorrhea; and without this impairment the condition will not be established.* This may be followed by another proposition, viz.: *Systemic conditions or a constitutional diathesis without local irritation do not destroy the integrity of the gingival border.*"

This quotation is made as it appears in a textbook of operative dentistry, and expresses the views of one committed to the local causation theory of pyorrhea. But these views are unsupported by any kind of experimental verification. Clinical observation alone is offered as the basis for the various expressed postulates, and clinical observation alone is not a safe warrant for axiomatic statements. Furthermore, the argument of the constitutional origin of pyorrhea does not preclude the contention that *any irritant of local origin which impairs the integrity of the gum margin may cause pyorrhea.* Neither does it conflict with the proposition that *systemic conditions do not destroy the integrity of the gum border.*

Those who argue for both local and systemic causes of pyorrhea contend that, in certain manifestations of the disease, local causes are entirely sufficient, and do fully account for the group of phenomena characteristic of the disease, but that in certain other manifestations of the disease, to be hereafter noted, local causes are not competent to fully account for the observed phenomena, and for the scientific findings recorded by carefully made chemical tests.

All attempts to narrow the argument to the cause of the gingival impairment must be inconclusive, therefore unsatisfactory. The gingival impairment is but *one*

feature of a true pyorrhetic condition. To make one factor the equivalent of the entire disease is obviously erroneous. Furthermore, the contention that *systemic conditions do not destroy the integrity of the gum border* is another form of the argument that pyorrhea alveolaris completely centers in the gingival impairment. This is not allowable. The testimony of many can be adduced to show that frequently pyorrhea can be conclusively diagnosed without the primary impairment of the gum border. In a paper entitled "Pyorrhea Alveolaris—Its Patho-Histology," published in the *Cosmos* for April, 1911, by A. Hopewell Smith, among other conclusions the following bears upon the above contention: *"Pyorrhea alveolaris does not begin as a gingivitis."*

In other words, the clinical and experimental data at hand concerning the disease under discussion, together with the most advanced knowledge concerning the diseases resultant from nutritional disorders, clearly indicate in an etiological sense a twofold classification, and all attempts to make one classification of pyorrhea dependent upon local causes end in confusion and failure, chiefly because they fail to disclose that scientific warrant, without which accuracy and impressiveness are lacking.

The same writer,[1] in accounting for deposits upon the roots of teeth, makes use of the following argument: "Now, as a matter of fact, all prominent pathologists agree that accretions of calcic matter may make their appearance as a deposit from purulent matter from inflamed territory *in any part of the human body*. Upon this subject I desire to quote from the 'Handbook of Medical Sciences,' Vol. 1, p. 743, as follows: 'Calcifica-

[1] Johnson's "Operative Dentistry."

tion consists in the abnormal deposit of earthy matter in or around the elements of a tissue, or *in the morbid product of a preëxisting inflammatory process.*' 'The circulation of the blood may be retarded and thus favor the precipitation of the calcareous matter which it normally holds in solution.' 'Calcification rarely, if ever, depends solely upon general causes. There is always a local influence—very often it is due to a preëxisting inflammation. Old accumulations of pus, extravasations, and exudations are exceedingly prone to calcification.' 'The simplest mode of explanation is as follows: A certain amount of calcareous matter is a normal constituent of the blood, in which it is held in solution by the carbonic acid always present in sufficient quantity to keep in solution twice the normal amount of earthy matter. When the circulation is impeded, the carbonic acid, because of its great diffusibility, is readily absorbed by the tissues, or goes to form new compounds, necessitating a precipitation of the calcareous matter. *This is likely to occur in all tissue of the body.*' "

In the latest researches by Dr. Black, published in the *Items of Interest* for June, 1911, bearing upon this subject, he writes as follows: "Though this matter has not yet been sufficiently studied, it seems evident that the deposit of the salts is called out by the presence of the agglutinin, and is not a falling of the calcium salts out of solution because of the loss of carbon dioxid, as taught by Dr. Burchard and others. It seems to be due to a positive chemotaxis existing between the salts in solution and the deposited agglutinin, or globulin, which calls the two substances together in this form." The investigations of Dr. Black appear to show that nearly all the conclusions, as set forth in the contentions previously quoted, made by those who so stubbornly resist

the systemic factor in certain forms of pyorrhea, faulty, and that, if any additional evidence were requ to sustain the view that certain forms of pyorrhea due to systemic causes, these latest researches of Black offer that confirmatory testimony.

"They (the deposits) are *not precedent* to a le but invariably *are subsequent* to irritation and ex tion." This is fully in accord with the writings of t who claim a systemic relationship for certain form pyorrhea, and therefore is lacking in value as an a ment subversive of this claim. Admitting, however correctness of the explanation of calcic formation cannot be made to serve as determining the etiolog pyorrhea in one classification of local causation. author of the above quotation admits that calcic dep from the saliva[1] may be the primary cause of a p rhetic involvement of the teeth. In what manner, can the relevancy of the admitted fact of tissue de eration as a necessary precedent to calcic deposit reconciled as an argument determining the etiolog pyorrhea? In the form of pyorrhea first describe Dr. Black, and designated by him phagedenic cementitis, the conclusion of this observer, as wel others, is that the calcareous deposits play a secon part in the etiology of this disease, and that at tim these cases no deposit can be detected. The writing Talbot, Kirk, and others, based upon advanced pa logical data, show quite conclusively that under ab mal nutritional conditions degenerative changes take place in the pericementum. With the develop of these changes the tissue so affected becomes liab pyogenic infection. In fact, the long-continued dist ance of the nutritive balance lessens the resistanc

[1] Johnson's "Textbook of Operative Dentistry."

the entire system to bacterial invasion. The formation of pus subsequently becomes the active factor of marginal impairment, and, perhaps, of the calcific deposits. But the origin of the pyorrhea, in these instances, is clearly associated with the disturbance of the nutritive balance. Hopewell Smith[1] first noted a fibroid degeneration of the pericementum. That this may be resultant of systemic conditions must be admitted, and that it may be a precursive condition of an active pyorrhea is a rational conclusion, and further emphasizes the probability of a constitutional origin, in certain instances, of pyorrhea. The argument may be further strengthened by the observations of many in active practice which attest to an occurring acute pericementitis, eventuating in a pericemental abscess, the origin of which appeared to be directly traceable to an acute digestive impairment resulting in autointoxication. The absorption of toxic substances from the intestinal tract into the blood and their transportation to the pericementum establish the predisposition to be followed by the acute infective process later observed. The pyorrhetic involvement that may follow is not difficult to comprehend, and clearly presents a systemic causation for such cases that should not be ignored.

Dr. Wm. Martin Richards[2] writes: "I have lately been impressed by the coincidence of pyorrhea alveolaris and sugar and albumin in the urine, and the disappearance of these symptoms when the teeth were cured."

In the above communication the inference is drawn that the cure of pyorrhea influenced a cure of the kidney lesion. It may have been that the converse of this really

[1] *Dental Cosmos*, 1904.
[2] *Journal American Medical Association.*

occurred. The susceptibility of diabetics to infecti has been quite definitely determined.

Dr. Kirk,[1] in a paper on "The Dental Relationshi of Arthritism," writes as follows: "In an elabor research made by Drs. John C. Da Costa and E. J. Beardsley, published in the *American Journal of t Medical Sciences* for September, 1908, it is shown fr an average of 50 cases of diabetes mellitus that the sonic index varied considerably with respect to strep coccus, to staphylococcus, and to tubercle bacillus, t three organisms employed in the tests. The average dex of all cases for each organism named was as follov Staphylococcus 0.65, streptococcus 0.56, and tuber bacillus 0.73. That is to say, the index was only a lit more than half normal for the ordinary pus-forming b teria, while it was scarcely three-fourths normal for bercle bacillus." It is regrettable that for our prese purposes the opsonic reaction to the pneumococcus w not also tested, that organism being so constantly cc cerned in invasions of the alveolar tissues. I have call attention to the work of Da Costa and Beardsley in ord to emphasize the fact that in diabetes mellitus the res tance to bacterial invasion of the pus-producing varie is greatly reduced below the normal standard, which fa in connection with the data I have brought forward show the prevalence of alveolar pyorrhea among diab ics and the prevalence of diabetes mellitus among tho of arthritic type, due to the effects of defective food ha its and prolonged overfeeding, is of much significan It serves to indicate that the phenomenon of bacterial i vasion is to a degree conditioned by the extent of t internal resistance of the tissues and body fluids of t organism, and, as resistance is lowered by the abnorm

[1] *Dental Cosmos*, July, 1909.

nutritional state which I have in general terms expressed here as arthritism, the invasion of disease-producing bacteria is not only more likely to take place in the first instance, but it is likely to become more grave and extensive when it does occur."

Classification.—In view of the data at hand, the division of pyorrhea into two classes is a rational procedure, and results in the utilization of more effective therapeutic measures than is otherwise allowable. *The first class* includes those cases in which the beginning of the disease is at the gum margin, induced by salivary deposits, banded crowns, the retention of food débris at the gingival border, and any other cause which impairs the vital activity of the tissues located at the gum margin, predisposing them to infective processes. *The second class* includes those cases in which the beginning of the disease is at a point between the gum margin and the apex of the root, induced by uratic deposits from the blood, or by such systemic conditions as lead to a vital impairment of the alveolar tissues, followed by pyogenic infection.

THE FIRST CLASS.—*Clinical History.*—These cases begin as a marginal gingivitis induced by any of the aforementioned causes. The hyperemic or inflamed gum tissue gives evidence of its engorgement by a hemorrhagic flow when pressure is exerted with a tooth brush or instrument. In some cases the pressure of the food during mastication is sufficient to cause a flow of blood. The gum tissue is excessively discolored and detached from the neck of the tooth. At times one-third or more of the crown is covered by the swollen gum. An instrument passed beneath the gum border usually detects the presence of discolored calculus. The deposit[1] may have

[1] Burchard's "Pathology."

taken place as a result of the reaction between the calcium salts of the saliva and the inflammatory exudations. The condition of the gum tissue favors its infection, which invariably follows, resulting in pus formation. This completes the characteristic phenomena of the disease. Unless remedial measures are now instituted, the destruction of the alveolar tissues proceeds until the tooth can be lifted from its socket with the fingers. With the loss of the tooth the disease is at an end.

Pathology and Morbid Anatomy.—The clinical manifestations of the disease indicate its pathology and morbid anatomy. The deposit of calculus irritates the pericemental fibers at the gum border, inducing a hyperemic condition. This is followed by inflammation and suppuration. Dr. Burchard[1] reports the finding of a ring of stripped cementum immediately beyond the calculus, inferring therefrom that the destruction of the pericementum precedes subsequent deposits. He also describes bead-like deposits of rough, hard, dark calculi upon the denuded cementum, similar to the deposits found in chronic septic apical pericementitis. These appear to be resultant from the pericemental degeneration, not causative of it, and are entirely distinct from the deposits found beneath the gum margin. The gum tissue overlying the deposit is darkened and swollen. The alveolar wall atrophies, and necrosis follows later. The stages of hyperemia, inflammation, degeneration, and necrosis of the pericementum successively involve the remaining fibrous tissue, with a corresponding atrophy and necrosis of the alveolar wall, until the entire root is stripped of pericementum, and infection of the apical tissues ensues, leading to pulp devitalization. The increasing looseness of the tooth may have predetermined

[1] Burchard's "Pathology."

the death of the pulp through strangulation of the apical vessels. At times the loss of the tooth is effected by the progressive atrophy, degeneration, and necrosis of the pericementum and alveolar wall caused by the pressure of the calcareous deposits, the infective features playing a subordinate part in the final tooth exfoliation. Such cases invariably belong to the classification of pyorrhea under consideration, exempt from any etiological systemic relationship, and may be explained by the existence of an active state of immunity to bacterial invasion, rarely, if ever, existent where the internal resistance to microörganic invasion has been lessened, as previously pointed out.

Diagnosis.—As no other oral pathological state is centered around the same group of phenomena, no difficulty is encountered in speedily forming a correct diagnosis. The presence of subgingival calculus, the hyperemic and detached gum tissue, the presence of pus in the pocket adjacent to the deposit, the partial destruction of pericementum and alveolar wall, and the evidence of tooth looseness afford an almost instantaneous insight as to the condition.

Therapeutics.—Concerning the plan of treatment to be followed for the eradication of the disease, quite a unanimity of opinion exists. Whatever differences exist as to the classification that may separate those in practice, these differences disappear when the therapeusis of the condition is discussed. A first essential requisite, as in the treatment of any other disease, is the elimination of the cause. If salivary deposits, ill-fitting crowns, improper occlusion, or any other local agency appears to be the direct excitant of the disease, or if two or more of these causes appear to be acting conjointly, their elimination is imperatively demanded. Without this, irre-

spective of what medicinal agents or other forms of treatment may be employed, no cure can be effected.

Having complied with this essential demand, the next step has in view the destruction of the factors of infection and the removal of necrotic tissue. The removal of the necrosed tissue is usually accomplished in the removal of the deposits. The injection into the pockets of a 10 or 20 per cent. solution of hydrogen dioxid, or a similar strength solution of any of the well known antiseptic solutions on the market, usually leads to the destruction of the infective processes. When marked hyperemia of the gum tissue exists, an application of 10 per cent. trichloracetic acid,[1] or full strength lactic acid,[2] will result in a notable contraction of the blood vessels and affords a much clearer field of operation at the second sitting. Some writers advise an application of the stearate of zinc to the surrounding mucous membrane as a protection against the caustic effect of full strength lactic acid. In the writers' experience, extending over a number of years, not one case has shown that any danger exists from the use of this acid. Recently a tartar solvent, the bifluorid of ammonia solution, has been introduced by Dr. Head. It is claimed that this agent will soften calcified deposits upon the roots of teeth without deleteriously affecting the tooth.

If the pyorrhetic condition has advanced to the stage of decided looseness of the teeth, it is most urgent before continuing treatment to bind the loose teeth to adjoining firm ones. For this purpose several well known splints have been in use for years. At times the operator's mechanical skill is severely tested to meet the exigencies of the case under treatment. The platinum band

[1] E. C. Kirk.
[2] Dr. Younger.

retainer, as shown in Fig. 45, is a very effective device. It is constructed by first binding the loose teeth together by means of ligature or thin regulating wire. "34-gage

FIG. 45.

platinum [1] plate is adapted to the lingual surfaces of the teeth; it is passed between the teeth to be splinted and those posterior, and its free ends are overlapped; a scratch is made to indicate the overlap, and the piece is detached and soldered. Returned to the teeth, the thinnest separating saw is passed between the teeth, grooving the splint deeply upon both sides; in these grooves straight strips of platinum plate are placed. If the piece can be lifted from the teeth without force, it is so displaced; if not, a plaster impression is taken, a cast of investing material made, and the strips soldered in their grooves." The appliance when completed is cemented in place. Splints can also be made with platinum or gold wire in the figure 8 form (Fig. 46).

Another form of splint is shown in Fig. 47. This combines efficiency with inconspicuousness, and may be

FIG. 46.

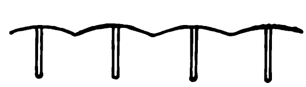

FIG. 47.

made to subserve the purpose of protecting the incisal edge from wear, in those cases where such procedure may be necessary. It is constructed in the following manner. The incisal edge is stoned down so as to re-

[1] Burchard's "Pathology."

lieve the occlusion. An inverted cone bur is next directed mesio-distally over each tooth to prepare a flat seat for an inlay. The walls are prepared nearly parallel, diverging slightly incisally; 24-k. gold plate, 36-gage, is annealed and accurately burnished to the cavity outlines. A hole is next drilled in each tooth sufficiently large to accommodate an 18 to 20-gage iridio-platinum pin, for a depth of about one-eighth of an inch. The matrix is placed in position and a pin is made to penetrate it to correspond to the drill pit in each tooth. An impression is taken of the matrices and pins in position, and a model poured of an investing compound. Sufficient 22-k. solder is flowed over the surface to restore the occlusion. When completed the appliance is cemented in position. After several days the patient is instructed to return, at which time a careful examination is to be made for remaining deposits. If any exist their removal is effected. With the splint in position the difficulties attending this are largely overcome. The pockets are flooded with an antiseptic wash, and if the gum tissue has not returned to its normal condition, a second application is made of either trichloracetic or lactic acid. The patient may now be dismissed for a longer period, providing he has been instructed in the efficient use of the brush, and given such other directions as the operator may consider necessary. These usually appertain to the means to be employed in removing food particles from between the teeth, and in the use of antiseptics.

The patient should be made to comprehend that the greatest good derived from the use of the tooth brush is not in having it pass over the surfaces of the teeth, but in its use so as to produce a gum massage. The beneficial effects of the brush so used cannot be overestimated. With many the finger massage of the gum tissue

constitutes the feature of the applied therapeutics in the treatment of pyorrhea. With the removal of the exciting cause, and those factors of septic complication which so materially aid in the destruction of the alveolar tissues, a favorable prognosis can be made. But the patient must be made to comprehend the importance of maintaining a strict oral hygiene, and of periodically presenting himself for prophylactic treatments, without which in the great majority of instances a return of the pyorrhea will be detectable.

Daily application of a mixture of 1 per cent. aqueous solution of iodin and 2 per cent. solution of iodid of potassium, or in severe cases concentrated form of iodin carefully applied, as: Zinc iodid, gr. xv; aquæ, ♏ x; iodin cryst., gr. xxv; glycerin, ʒiii, is also advantageous.

Second Class.—Pyorrhea alveolaris, beginning upon the lateral aspect of the tooth root induced by uratic deposits, or by such systemic conditions as lead to a vital impairment of the pericementum and alveolar wall, resulting in degeneration and predisposing these tissues to infective processes terminating in suppuration.

It is this class which has given rise to almost endless discussion, and notwithstanding the close clinical observations recorded by such investigators as Peirce, Kirk, Talbot, Burchard, and others, together with the experimental verification given the deduction that at least one form of this class is due to the deposition of uric acid, urates, and calcium salts in the pericementum, which the work of Peirce fully sustains, many in the profession ignore the results upon which rests the belief in the systemic origin of these forms of pyorrhea. This disregard of the evidence which fully justifies the classification of pyorrhea under two heads, according to the operation of local or systemic causes, seems to be almost en-

tirely induced by the so-called cures effected through local means only.

The contention of those who recognize no systemic etiological factor of pyorrhea chiefly deals with the curative effects of local therapeusis. It also emphasizes the claim that without marginal impairment pyorrhea is not established, and, furthermore, that systemic conditions do not bring about this marginal impairment. Local therapeusis must ever be an important feature of any attempt to deal with pyorrhea. This has been emphasized in discussing the first classification, and is as applicable in the treatment of those cases which belong to the second classification. This is evident from a comprehension of the pathogenesis of the disease, but does not establish a warrant for the claim of the local causation of all forms of the disease. Many of the so-called cures of pyorrhetic cases are cures only in the sense that the gum hyperemia has been reduced, and that the infective processes have been temporarily destroyed. Shortly thereafter the disease reappears, not because lack of oral hygiene allows of the return of the pathological features of the disease, but because the local measures primarily employed in its treatment failed to correct the underlying systemic factor. The other contentions concerning marginal impairment, so insistently urged by the opponents of the systemic relationships of pyorrhea, have no basis in experimental verification.

Reference has been made to an article by Dr. E. C. Kirk[1] on "The Dental Relationships of Arthritism," in which evidence is adduced in support of the claim of the systemic origin of certain forms of pyorrhea. The following paragraph is quoted from the same article in further corroboration of this view:

[1] Cosmos, July, 1909.

"Prof. Dr. Van Noorden of Frankfurt a. M., in his monograph on 'Diseases of Metabolism and Nutrition' says: 'Within recent years the idea has become firmly established in the minds of physicians that a variety of morbid phenomena are due to autointoxication—are, in other words, attributable to certain poisonous metabolic products. This view, it is true, is not new, for it was familiar to the physicians of past generations, and was part of the teachings of the medical folk lore of long ago. It was not, however, until Bouchard and his pupils published their investigations on the subject of autointoxication that this theory attained the dignity of a scientific doctrine. At first we German physicians were by no means inclined to accept the theory of autointoxication that was being so enthusiastically proclaimed. Of late years, however, our attitude has become more friendly to the doctrine; this change of front is due to the fact that a number of toxic products of metabolism have actually been isolated, and their mode of origin in the organism and their pathologic effect determined to the satisfaction of the former critics of the doctrine. We do not, of course, know all that we should properly know about the poisonous metabolic products that we incriminate in so many morbid states; but in a large group of important symptom-complexes we are fortunately in possession of a number of facts that suffice to ground the doctrine of autointoxication on a solid chemical basis.' "

Dr. Kirk later says: "I have made the foregoing quotation from an eminent exponent of German scientific conservatism to emphasize the fact that the doctrine of autointoxication as a factor in disease causation, and as a prodromal state of bacterial invasion, rests upon an accepted scientific foundation."

Dr. Talbot,[1] in a paper before the National Dental Association, "Acidosis, Indicanuria, Internal and External Secretions: The Effects upon the Alveolar Process and Teeth," after discussing the various effects of these uric substances upon the pulp and alveolar structures, says: "A reduction of acidosis and indicanuria—two of the visible signs of toxins in the blood—and a preservation of normal conditions, will overcome many of the pathologic conditions found in the mouth." The same writer, in an article, "Treatment of Interstitial Gingivitis,"[2] says: "It has been demonstrated many times that interstitial gingivitis is due to both local and constitutional causes," the constitutional causes referred to being "excessive urinary acidity and indicanuria." Michaels, in his studies of the saliva, and others have constantly called attention to the singular immunity to caries shown in the dentures of those of the *hyperacid* type, and the general susceptibility to alveolar affections of the same class of individuals.

These various quotations have been given chiefly to indicate the data now at hand which clearly relates, in an etiological sense, certain forms of pyorrhea with systemic conditions, and scientifically warrants the classification of this disease as herein made.

Clinical History.—The teeth generally affected with pyorrhea show an almost universal immunity to caries. In the second class the pulp reveals the effects of a long-continued irritation in the excessive formative activity, as shown by its contracted mass and the increased dentinal formations. One case is recorded[3] as showing a "loss of odontoblasts over a considerable surface of pulp

[1] *Cosmos,* 1908.
[2] *Cosmos,* 1909.
[3] Burchard's "Pathology."

periphery." A general tendency to mechanical abrasion and erosion is also shown. Later the teeth begin to loosen, and if the causes are allowed to go on, finally drop out. Patients frequently report that several of their teeth, without any evidence of caries, progressively loosened until they were removed with the fingers. At times the change of position of a tooth, or teeth, may impress itself upon the patient. This is to be especially noted in the so-called *phagedenic pericementitis* of Black. In this latter class an acute pericementitis with its concomitant of acute pain induces the patient to consult the dentist. In the majority of cases, however, the progress of the disease has almost reached the stage of exfoliation before the condition is brought to the attention of the dentist. If the condition is due to uratic deposits in the pericementum, or to the deposition of other toxic agents circulating in the blood, questioning on the one hand reveals the patient's relationship to the diseases of arthritism, or else urinary examinations usually reveal an increased acidity and indicanuria. The absence of these substances from the urine, or their normal finding at the time of examination, should not be accounted as decisive proof that the alveolar affection bears no relationship to a condition of autointoxication. This has been pointed out by Talbot. The tooth reveals tenderness upon percussion and the gum tissue is hyperemic. But in these cases, in the early stages, *no marginal gingivitis or impairment can be detected.* It is only after pyogenic infection has occurred and the pus discharged at the gingival margin that the impairment, so strongly insisted upon by those who disregard the systemic relationship of this class of pyorrhea, can be noted. In the gouty form a swelling of the gum near the apical region may be observed; a probe introduced into this

swollen gum reveals a necrotic alveolar wall and deposits upon the root immediately beneath the swelling. The clinical manifestations, at times, reach their severest expression in all the characteristic phenomena of pyorrhea, and the only rational procedure is removal of the tooth.

Pathology.—The pathology of this class of pyorrhea requires consideration, both as to *systemic* and *local* manifestations.

Magitot and many observers who followed him have frequently directed attention to the relationship apparently existing between the so-called gouty diathesis and pyorrhea, and expressed their belief that the local condition was induced by the disturbed nutritional balance which the systemic condition indicated. As has already been noted, Dr. Peirce's investigations supplied the scientific basis which the earlier observations lacked, and made the view of the systemic origin of certain forms of pyorrhea, called by Dr. Peirce *hematogenic calcic pericementitis,* a demonstrated fact.

Whether the gouty diathesis is viewed as being due to an excessive intake of nitrogenous food, or to imperfect elimination by the kidneys of the final metabolic change of these foods, or to an impaired hepatic function which fails in the elaboration of urea, or to a general condition that may be classified as one of suboxidation, or to a combination of these states, the fact remains, and is almost universally accepted, that the urate of sodium is retained in the blood and deposited in the tissues, exciting a series of pathologic phenomena quite well known and accurately classified. That the urate of sodium may be deposited in the joint formed by the root and the alveolar wall is just as readily acceptable as that it may be deposited in any other joint of the body. That the peri-

cemental tissue elements must be primarily affected with degenerative and necrotic changes which establish the predisposition, without which these deposits do not occur, does not in any way alter the systemic relationship of this form of pyorrhea as herein expressed. As has been stated, Hopewell Smith reports his finding of a fibroid degeneration of the pericementum. This may follow altered systemic conditions. Uratic deposits occurring in such tissues are generally followed by inflammation; the affected area now becomes an easy prey to pyogenic infection. With this the active factors of the pyorrhetic conditions are in full operation. The alveolar wall and pericementum melt down, the tooth loosens, the gum tissue becomes hyperemic, probably inflamed, and additional calcic deposits occur, which in many cases, as stated by Peirce, cover the primary uratic deposit. These same pathological manifestations may follow when the pericemental predisposition has been established in any other way.

Therapeutics.—The treatment of pyorrhea belonging to the second classification is both local and general.

The local treatment is based upon the same lines as indicated for the form of pyorrhea grouped under class one. The tooth root is to be freed of all deposits, the inflammatory and suppurative processes checked, and the loosened teeth mechanically supported.

The general treatment is based upon principles corrective of the systemic conditions. For this the patient should be referred to the physician. The necessity for this should be clearly defined in a free discussion of the underlying pathologic features of the disease. Whether the disease is due to either increased formation or diminished elimination of uratic salts, or to a state of the system expressive of an altered nutritional condition,

related perhaps, but not identical, with the "uric acid diathesis," such as we find in the increased urinary disclosure of indican, or to other toxic substances floating in the circulation, associated with a condition of suboxidation, medical therapeusis must be made operative with the dental in order to secure more permanent conservation of the teeth.

Recently the value of bacterial vaccines in the treatment of pyorrhea has been under discussion. Dr. Arthur H. Merritt,[1] in a paper entitled "The Application of Bacterial Vaccines to the Treatment of Pyorrhea Alveolaris," says: "Pus from the depths of a pyorrheal pocket is transferred to a culture tube, sealed, and sent to the pathologist, together with smears, who determines the variety of the organism or organisms, grows them artificially, and from these prepares the vaccine. The inoculations are made usually in the interscapular region about once each week, the number of such inoculations and size of dose depending upon the case." Dr. Merritt also reports several cases where the use of the vaccines was followed by a decided improvement in the pyorrheal condition, and concludes with the following paragraph:

"To sum up then, it would seem not unreasonable to say that the treatment of pyorrhea with bacterial vaccines is a perfectly rational one; that in some instances local treatment only is required, making the employment of bacterial vaccines unnecessary, and showing the need for careful discrimination in their use; that in still other cases it is essential that nature's reactive forces be stimulated, if we are to expect anything more than temporary improvement; that the more chronic cases may be accounted for by the fact that a subnormal

[1] *Dental Brief*, October, 1909.

opsonic index is characteristic of some individuals, having been acquired or inherited; that while the reaction to bacterial infection may be normal, there may be, as the result of poor circulation, a localized tendency to infection."

To determine the value of bacterial vaccines in the treatment of pyorrhea will require considerably more experimentation. That it may become a valuable aid in the treatment of those cases in which a lowered opsonic index exists toward the pus cocci, in consequence of which the chronic suppurative condition is not destroyed by the use of the ordinary antiseptic measures, is a reasonable deduction. Ever since Wright, of London, and others have demonstrated that we recover from infective diseases, or processes, by the development of specific bodies, which so affect the invading organism that the leukocytes are enabled to destroy them, this mode of therapeusis (bacterial vaccines) is to be at all times seriously considered in relation to the treatment of infective conditions. But a close study of the clinical features and etiology of pyorrhea will reveal the necessity for the utilization of other measures previously discussed, without which the hope of effecting a complete cure cannot be reasonably entertained, notwithstanding the valuable aid that may be rendered toward a cure by the use of bacterial vaccines.

CHAPTER XIII

FILLING MATERIALS—THEIR ATTRIBUTES—METHODS OF MANIPULATION AND CONDITIONS WHICH INDICATE THEIR USE

It is quite apparent that our knowledge concerning the problem of caries is far from being complete. It is also quite obvious that not until the complete solution of this problem has been effected can we hope to attain better results in tooth conservation. But in order to do this the knowledge of caries, no matter what complete state it may reach in the future, must be supplemented by a knowledge of the attributes of the materials utilized in filling cavities of decay, also the conditions which indicate the use of the different materials, and the methods of manipulating them. Fortunately our knowledge concerning the latter requirements may be said to be far more complete than that of the great problem of caries, and it is in a large sense owing to the accurate although not complete knowledge in our possession concerning the physical characters of the different filling materials, and the methods of utilizing them, that we are enabled at times to successfully combat the factors of caries.

The materials to be considered are gold, tin, amalgams, oxyphosphates, oxychlorid, and gutta percha. Porcelain has been discussed in the chapter on Inlays.

The ideal filling material is one upon which the oral fluids have no effect. It should have sufficient tenacity

when condensed to resist the forces acting upon it. It should neither shrink nor expand after insertion in the cavity. It should be perfectly adaptable to cavity walls; harmonious with the color of the tooth; non-conducting; non-irritating; and allow of a convenient introduction. In other words, it should be easy of manipulation.

GOLD

The pliability and softness of gold, which allow of its perfect adaptation to cavity walls, and its resistance to the action of the oral fluids no doubt established its early recommendation as a filling material. It neither shrinks nor expands, and when properly condensed fully resists the forces acting upon it. In these respects gold fully meets the ideal requirements. Its color is objectionable, and, although the high yellow color may be somewhat subdued by the addition of platinum, it still retains a strong contrast to the shade of the tooth. Dr. Black[1] states that a well-finished gold filling shows just what it is and may be less offensive to the esthetic sense than a poorly matched porcelain inlay. With this statement many operators will fully agree. Gold is also highly conductive of thermal impressions; and its successful manipulation is only acquired after considerable studious experience.

For filling purposes gold is prepared in two forms, *foil* and *crystal*.

Gold Foil.—Gold foil is prepared in different thicknesses designated by numbers made to represent the number of grains contained in each sheet four inches square. Number four foil contains four grains to each sheet; number ten contains ten grains, and so on to the heavy foils containing sixty, one hundred and twenty,

[1] Black's "Operative Dentistry."

and some a greater number of grains to each sh These heavy foils are but little used to-day in fill cavities.

Gold foil is also prepared as *cohesive* or *non-cohesi* Probably for the first half century of its use it w utilized only as *non-cohesive* foil. With the discovery its cohesive property, the application of gold in den restorations was greatly enlarged, and marks an epo in the evolution of operative dentistry. For the prop use of cohesive foil no foreign substance can be allow to deposit upon its surface. If this takes place its c hesiveness is destroyed and the operation will resu in failure. Gold does not oxidize, as do the baser me als, nor does it attract oxygen to its surface, as do silv and platinum,[1] but it does attract to its surface oth gases from the atmosphere which, from careful stuc Dr. Black reports to be, most likely, acid gases. Ther fore, he suggests that, if a solution of ammonia is co veniently placed, ammonium salts will be formed on t surface of the gold, protecting it from other gases. T deposition of the ammonium salt renders the foil no cohesive, but as annealing effects ready volatilization the ammonium salt its cohesiveness is completely r stored. The same book of foil may be used either non-cohesive or cohesive, by placing it near a spon containing spirits of ammonia. Used without annealii this will be perfectly non-cohesive; annealed, it will cohesive.

In the annealing of gold to render it perfectly c hesive, Dr. Black urges the importance of bringing eve particle of the gold to a glow in order to insure t complete volatilization of the substance that may ha collected upon the surface of the foil. This is the cour

[1] Dr. Black, "Operative Dentistry."

to be pursued when annealing gold in the flame of an alcohol lamp or small Bunsen burner. But as this method of annealing is open to several objections, a better plan is not to expose the gold to the naked flame, but to place it preferably in an electric annealer or upon mica, where it is free from handling, and where sufficient time may be allowed to insure a thoroughly clean working surface. Dr. Black emphasizes the importance of thorough annealing, especially where an angle is to be built out, and states that the pitting of the surface of the filling is due to the use of pieces of gold that have not been thoroughly annealed.

Non-cohesive Foil.—Non-cohesive foil is now rarely employed, excepting, perhaps, in filling the first third of a cavity, where its greater pliability and time-saving feature may be special factors, or in instances where the surrounding walls of simple cavities are capable of withstanding the force of the wedge principle, upon which its successful introduction depends. Occlusal cavities in molars, or labial and buccal cavities, may be advantageously filled with non-cohesive foil, and the many fillings of twenty and thirty years' standing, still doing service, bear excellent testimony to the service rendered by non-cohesive foil. In filling with non-cohesive gold, cylinders of varying sizes, or ropes of foil, are used. The size of cylinder selected should depend upon the depth of the cavity. One that in length slightly exceeds the depth of the cavity, and when loosely rolled about fills the cavity, is selected and placed in position and pressed against the distal wall with the side of the plugger, and held in position with an instrument to prevent movement. This is repeated until one-half or more of the distal portion of the cavity is filled. The same method is pursued against the remaining walls until

the cavity is quite filled. As this progresses it will be necessary to use smaller and smaller cylinders, until finally, to obtain room for more cylinders, a wedge instrument is pushed into the gold and condensed against the walls; the space thus obtained is again filled with cylinders, and the wedging continued until it is impossible to provide space for more gold. The surface of the filling may now be condensed with a finely serrated plugger, and partially trimmed down, again condensed and trimmed down, until the surface is as hard as it can be made, and flush with the cavity margins.

COHESIVE FOIL.—The introduction of cohesive foil made possible the restoration of seriously impaired carious teeth, which formerly could not be restored with non-cohesive foil, but, unless this is used intelligently, failures will ensue. If large masses are introduced, as in filling with non-cohesive foil, most likely faulty adaptation and condensation will result. Therefore, in the use of cohesive foil, *small* pieces should be welded together. This allows of perfect adaptation, which is essential to a good filling. Dr. Black reports that in his examination of gold fillings, introduced by different operators, many showed faulty adaptation to cavity walls, although the condensation was good, this apparently being due to improper laying of the gold against the cavity walls, the improper placing of the plugger point upon the gold, and improper application of force. It is quite evident that such fillings, no matter how dense, are very apt to move under heavy stress, because the cavity walls have not sufficient sustaining grasp, as Dr. Black explains it, upon them. With the modern methods of cavity preparation the nature of the occlusion, involving a study of the forces acting upon the filling, has a direct bearing upon the preparation of the cavity, so that

suitable provision may be made against displacement, providing, of course, that the gold is properly adapted to the cavity walls and sufficiently well condensed.

The form of cohesive gold used is that of the sheet folded, or else rolled, into a rope, and cut into suitable sized pieces; or the cylinders prepared by the supply houses. Dr. Black's preference is for the block which he prepares by cutting No. 4 foil into 4-8-16-32 pieces. Each of these is crumpled together and formed into a loose ball. This is formed into a block by means of a pair of flat-nose pliers. Dr. Black regards this form as affording most positive and rapid results. Each operator soon develops a liking for a particular form which he learns to use most deftly. So, too, with the particular kind of force used in condensing the gold; some prefer the hand mallet used by an assistant, which Dr. Black regards as being by far the best, as it will produce the desired result with least wear and tear to both patient and operator. Others combine hand and mallet force.

Another factor that may determine the character of force to be utilized in condensing the filling is the condition of the pericementum. Reference has been made in discussing inlays that at times an inlay may be well advised in place of a foil filling, because the condition of the pericementum may argue against the application of force necessary to properly condense a gold filling. The condition of the pericementum may argue in favor of the hand mallet, in the face of which it would be unwise to employ either automatic or electric mallet.

A great variety of instruments are designed to meet every need of the operator in filling teeth with gold. Most operators soon learn to use most deftly certain forms, and these meet all their requirements. The car-

dinal principles that at all times must be observed, after the cavity has been properly prepared, are *perfect adaptation* and *adequate condensation.* Selections made from the Webb or Varney set of plugger points, or from any other set in ordinary use, usually meet all requirements. The serrations should not be deep, and preference should be given to those with rounded corners.

Crystal Gold.—Considerable difference of opinion seems to exist concerning the value of this form of gold for filling cavities. Failures attending its use have been due, as a rule, to its too hasty introduction into cavities. This does not allow of a proper degree of condensation, and is very apt to result in imperfect adaptation; in either case a faulty filling is the result. To insure a good filling, this form of gold should be well annealed and introduced in small pieces, which may be adapted to the cavity walls, first, by hand pressure, after which mallet force may be used. But care must be exercised that perfect adaptation has been secured, also an adequate degree of condensation. Dr. Black's experiments appear to show that under the same force the crystal gold fillings did not approach in density the foil fillings,[1] but there can be no question concerning the possibility of making just as permanent fillings with this form of gold as with foil, providing it is properly utilized. "There is no preparation of gold better adapted for starting fillings in shallow or irregular cavities, or for surfacing fillings. Many operators make use of it always for starting and for finishing fillings."[2] But the beginner must be careful to avoid the pitfalls so easily created in the use of crystal foil. Good fillings can only be made if proper regard is paid to the avoidance of

[1] *Dental Digest*, September, 1909.
[2] Dr. Darby, "American Textbook of Operative Dentistry."

those errors that so easily result in a faulty filling, either from imperfect adaptation or else inadequate condensation.

Simple Cavities.—Simple cavities upon exposed surfaces, such as occur in the fissures of bicuspids and molars, and in the pits of the lingual surfaces of the superior anterior teeth, are the easiest to fill. If the margins of the cavity in this class of cases have been extended to such parts of the tooth as will enable the operator to give the proper finish to the filling, little additional cutting will be necessary. An occasional exception to this will be found in second and third molars, and especially in the lower molars with decided lingual leaning. In these cases it may be necessary to cut the mesial and buccal walls in order to allow of the proper approach with the condensing instruments. In filling these cavities much time may be saved, as well as inconvenience to both operator and patient, if one-half or even two-thirds of the cavity is filled with non-cohesive foil. Or the entire cavity may be filled with crystal gold with a greater conservation of time and energy without the slightest sacrifice in result. Non-cohesive cylinders of suitable size are adapted to the distal wall of the cavity, and between the buccal and lingual walls, until wedged in position. Cohesive foil is then incorporated into the non-cohesive until a solid foundation is secured, upon which the filling may be completed with cohesive foil. If crystal gold is used it is adapted against the distal wall and between the remaining walls by means of hand pressure. When securely anchored it is to be further condensed with a small-sized foot plugger in the automatic mallet. If care is exercised in accurately adapting additional pieces of gold, first, by hand pressure, to be followed with the automatic mallet, perfect filling opera-

tions may be made with considerable saving of time and inconvenience.

Proximal Cavities in Incisors and Cuspids.—These cavities are difficult to fill in proportion as they are inaccessible. If the margins have been extended lingually and labially to the immune areas of the tooth, and sufficient space has been secured by wedging, they are easy of approach to all parts excepting the incisal anchorage. As a rule the lingual wall will be cut away more than the labial, for esthetic reasons, and the approach will be made from the lingual aspect. However, with proper extension of the margins and sufficient separation the labial approach will be more convenient, and the lingual wall need not be unduly cut away. The axio-linguo-gingival convenience point is first filled from the labial aspect. Then the labio-axio-gingival point angle is filled from the lingual approach, and the two connected by filling the gingival line angle. Figs. 48, 49, 50, and 51 show


FIG. 48.


FIG. 49


FIG. 50.


FIG. 51.
(After Dr. Black.)

the various steps in the operation. The filling is kept in advance lingually and built out and over the cavo-surface angle to its full contour, until the incisal retention is reached. This should be filled in with hand pressure. The filling is now built out to the contact point, and, unless sufficient space has been provided, it will be almost impossible to properly prepare this part of the filling. The operator must bear in mind that thorough condensa-

tion is important in these fillings; therefore every portion of the operation should be gone over very carefully in order to be assured that no weak spots remain that might result in early failure of the filling.

Proximal Cavities in Bicuspids and Molars.—A chief requisite in the filling of this class of cavities lies in

FIG. 52.

FIG. 53.

FIG. 54.

the creation of the necessary space that will enable the operator to reach every part of the cavity, and to build it out to the full contour; otherwise a faulty operation must inevitably result. Figs. 52, 53, 54, 55, and 56 illustrate the various steps in the operation, assuming that the rubber dam is in position and that the necessary

FIG. 55.

FIG. 56. (After Dr. Black.)

space has been secured. The illustrations show the various steps, using cohesive foil throughout the entire operation. Dr. Darby[1] recommends the use of *crystal gold* at the cervical border in those cases where the cavity has no great depth and the retaining grooves are shal-

[1] "Textbook of Operative Dentistry," Kirk.

low; or non-cohesive foil may be used, allowing it to extend over the cervical border. The upper third of the cavity may be filled in this way, after which cohesive foil should be used. But care must be exercised that a solid foundation is made for the cohesive foil. Dr. Black[1] warns against the attempt to build the gingival line angle from one point angle to the other, condensing a thin layer of gold, or with force applied, perpendicular to the plane of that wall. The attempt to so build the gingival line angle will result in imperfect adaptation. The elasticity of cohesive foil is almost nothing, but as soon as it is subjected to force it hardens and acquires a degree of elasticity that will prevent perfect adaptation. Dr. Black also urges the packing of the gold toward the cavity wall and the placing of the gold between the last portion condensed and the wall. This enables the operator to make a perfectly adapted filling, whereas, if the condensing is away from the wall, the tendency would be to pull the gold away, resulting in imperfect adaptation.

Cases with Loss of Incisal Edge.—In those cases where the incisal edge has been lost through abrasion, and it is deemed necessary to restore the lost portion, as shown in Figs. 57, 58, and 59, the foundation for the

Fig. 57.

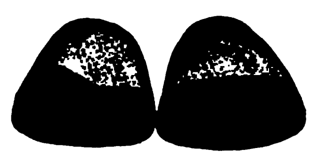

Fig. 58.

filling is prepared in a flat seat with square angles formed with the surrounding walls. These fillings must be built strong enough to withstand the force of the

[1] Black's "Operative Dentistry."

lower teeth almost constantly acting against them. Some operators complete these fillings with No. 20 platinous gold, the use of which gives a very dense surface to these fillings and subdues the bright yellow of gold. This manner of completing these fillings is viewed with particular favor in those cases which demand the building up of the filling so as to open the bite.

Fig. 59. (After Dr. Black.)

Finishing.—The correct finishing of the filling is as necessary for its permanency as any other important step, from the correct preparation of the cavity to the final placing of the last piece of gold. In fact it may be said that the finish of the filling generally reveals the thoroughness of the previous stages of the operation, although carelessness in the final touches to the filling may lead to early failure, even though every other stage of the operation has been carefully planned and executed. The filling, when finished, should be so related to the enamel margins that a delicate explorer may be passed from the tooth to the filling without any catch. Furthermore, the exact form of the tooth should be reproduced.

In exposed fillings, such as occur upon the occlusal surfaces of molars, or in the gingival third of incisors and cuspids, a satisfactory finish to the filling is not difficult of attainment; but in proximal fillings the difficulties are much greater. That part of the filling that is to form the contact point is built out to excess. It is made to touch the proximating tooth, even though the teeth have been separated. As a first step in the finishing this excess may be reduced by passing a saw between the filling and proximating tooth. The excess

at the gingival margin may now be removed, and the greatest care exercised that the filling at this portion be properly related to the tooth. By means of cutting instruments, files, stones, tape, disks, etc., the filling may be made to take its proper finish. It does not require extensive experience to impress upon the operator the great importance, in proximal fillings, of a properly shaped contact point, including a correct form of the proximal surface. In discussing the etiology of caries it was found that the beginning of decay occurs at such points as favor lodgment of food and bacteria, inviting fermentative changes. It was also found, later on, that extending the margins of a cavity and building out to a properly formed contact point lead to the rubbing of these margins by the food in mastication through the embrasures, and prevent the lodgment of food débris between the teeth, which, if occurring, not only results in early recurrence of decay, but also in serious injury to the gum tissue and pericementum. The closest study of the forms of the teeth, and the vital necessity for their reproduction when lost through caries, together with much patient effort, will finally lead to the development of a degree of skill necessary for permanent operations.

TIN FOIL

The use of tin foil in cavity restoration is at the present time rarely resorted to. Its constantly decreasing use bespeaks for it an obsolete position in operative dentistry in the not distant future. This is due to the few commendable qualities it possesses as a filling material. Its color is objectionable, owing to its quick oxidation, which also destroys its cohesiveness, so that, unless freshly cut from a pure ingot when intended for

use in a cavity, it cannot be worked upon the cohesive principle. It is unable to resist attrition, which limits its use to places not exposed to mastication. It is readily adaptable to cavity walls and shows no alteration in form, excepting that resulting from attrition. Its conductivity is far below that of either gold or amalgam, and in this regard possesses a decided degree of superiority compared to either of the other materials. It is occasionally recommended as a non-conducting medium for gold fillings. Much has been written concerning its supposed therapeutic value at the *vulnerable portion* of gold fillings, viz., the gingival margin. These recommendations appeared mostly at a time when the causes of recurring decay were not understood, and do not appear to impress many, if any, at the present time. It is prepared chiefly in foil form, Nos. 4 or 8 being generally used, and may be used in deciduous cavities which demand an easily introduced material. But amalgam would subserve a more permanent purpose. If the cavity lacks retentive form for amalgam, and the operator does not deem it prudent to proceed with the shaping of the cavity to make it retentive, the oxyphosphate of copper may be employed. This material is rapidly assuming an important place among our filling materials, especially in filling cavities in deciduous teeth. The introduction of tin is similar to that of gold foil, and the filling is finished in the same way as a gold filling.

AMALGAM

An amalgam is a union of one or more metals with mercury. *Copper amalgam,* a binary amalgam, is prepared by adding precipitated metallic copper to an excess of mercury; when thoroughly plastic the excess mercury is removed through chamois with wafering

pliers, packed in molds, and allowed to harden. When intended for use a wafer is held in an iron spoon over the flame of an alcohol lamp until small beads of mercury appear upon its surface; it is then rubbed in a mortar into a plastic mass, and inserted in the cavity. Many fillings made of copper amalgam have made most excellent records; on the other hand, many proved to be miserable failures, due apparently to improper preparation of the amalgam.[1] The presence of oxids of either mercury or copper in the filling sets up electrolytic conditions which prevent the formation of the blackened surface seen in all permanent fillings made of this material, and finally lead to its almost complete dissolution.

Since Dr. Black's work on the physical properties of amalgam, alloys are prepared consisting of four metals, silver, tin, copper, and zinc. The first dental amalgam [2] was prepared by filing a silver coin consisting of silver, 9 parts, copper, 1 part, and mixing with mercury. This was the "silver paste" of Taveau and the material later introduced into America by two charlatans named Crawcour, and named by them "Royal Mineral Succedaneum." The history of amalgam following its introduction by the Crawcours is invested with a peculiar interest, because of the ignorance which ascribed almost all the ailments "to which flesh is heir" as being due to the presence of mercury in amalgam fillings. This placed a ban upon the material, which was only partially relieved when Dr. Townsend advocated the use of amalgam in cavities which could not be filled with gold, and introduced the so-called Townsend's alloy, consisting approximately of tin, 55, silver, 45. The failure of the

[1] Dr. Burchard, Kirk's "Operative Dentistry."
[2] Flagg's "Plastics."

fillings made from this alloy, due to causes now well understood, but not comprehended at the time, resulted in a second condemnation of the material, without any attempt being made to ascertain the causes of the failure. Fortunately for the subsequent history of amalgam, Dr. J. Foster Flagg, about this time, became interested in the material, due to the conservation of badly decayed teeth which had been filled years before with coin amalgam. Dr. Flagg's first act was the reversal of Dr. Townsend's formula. The change to the decided increase of silver and lessening of tin was followed by such noticeable improvement in the fillings made of this alloy that further experimentation and patient observation finally led to the evolution of several dental alloys, the history of which is part of the history of dentistry, and stands as a monument to the genius of Dr. Flagg and to the work of the "New Departure Corps."

The work of the "New Departure Corps" stood as final in all questions dealing with plastics, until the investigations of Dr. Black, which first appeared in the *Cosmos* for 1895. Dr. Black's work in part was a scientific determination of the physical properties of amalgams, corroborating in a large degree the clinical records of Dr. Flagg, also establishing other important knowledge concerning amalgams, chief of which was the property of "flow."

Physical Characters of Amalgams.—It is quite evident that an amalgam mass, after its insertion in a cavity, undergoes certain changes aside from its hardening. Most important of these changes are those due to either *contraction* or *expansion* of the amalgam.

The contraction or expansion of the amalgam is primarily due to the constituent metals of the alloy, the proportions in which these metals are used to make up

the alloy, and the relation which these metals bear to each other as *alloyed* or *mixed*.

The amount of mercury used in making the amalgam modifies the degree of contraction or expansion, but does not control it. To produce an alloy that will show no change during the hardening process depends, as Dr. Black puts it, "on the correct balancing of the metals of the alloy." The experiments of Dr. Black also disclosed the fact that annealed alloys of 70 per cent. or less of silver and 30 per cent. or more of tin, when made into amalgams, all shrank, while those containing more than 75 per cent. of silver expanded. The proportion of silver and tin to yield a good working alloy was found to be about 72½ silver and 27½ tin, the proportion of silver to be modified by the addition of some other metal which, according to Dr. Black's present view, he limits to about 5 per cent. of copper. This he regards as desirable, providing it is alloyed with the silver before adding the tin. The addition of zinc, even in the proportion of one-half of one per cent., effects a change of bulk in the amalgam which finally ends in failure, so that he now advises against the addition of zinc as a constituent of a dental alloy. This is important, as most of the alloys placed upon the market, after Dr. Black made known his researches, consisted approximately of silver, 67, tin, 27, copper, 4½, zinc, 1½. The elimination of zinc from dental alloys changes the formula to silver, 67½, tin, 27½, copper, 5. This resembles the formula of Dr. Flagg's *submarine alloy*, which consisted of silver, 60, tin, 35, and copper, 5. The increase in the proportion of silver from 60 to 67½, and the corresponding decrease in the proportion of tin, must affect the amalgam mass very favorably excepting in the degree of discoloration that finally takes place in the mass.

Amount of Mercury.—The amount of mercury used in making the amalgam mass has a bearing upon the final result. An excess or deficiency in the amount of mercury appears to weaken the amalgam mass, too much mercury being more faulty in this regard than too little. If the excess, however, is promptly removed from the amalgam mass, but little, if any, injury will ensue. The amount of mercury necessary to make a plastic mass is, in a degree, governed by the length of time the alloy has been annealed. The more it has been annealed the less mercury is used to bring about the desired degree of plasticity, and the slower the setting of the amalgam mass. The strength of the amalgam is also reduced. It is for these reasons that the proportions of alloy and mercury should be secured by weight; in no other manner can the correct proportions between the two be estimated.

Distribution of Mercury.—An uneven distribution of the mercury affects unfavorably the amalgam mass. If the mercury is added to the alloy in a manner which allows an excess in one portion and a deficiency in another, the amalgam mass is weakened, in the same way as when either an excess or deficient amount of mercury is used to make the amalgam. An even distribution of the mercury throughout the alloy is necessary, and this is obtained by thoroughly kneading the amalgam mass until it is capable of taking the skin markings.

Flow.—The "flow" of amalgam is the change of form, or the movement of an amalgam mass, when subject to stress. Dr. Black found that an amalgam made of an allow of silver and tin showed its *flow* in proportion to the tin it contained. Alloys containing less than 60 per cent. of silver make amalgams that flow when very

light pressure is applied. In copper amalgam the flow is at zero. Those alloys containing 60 per cent. silver and 5 per cent. copper and the balance tin stand next in showing the least degree of flow. Apart from the contraction or expansion of an amalgam, the property of flow as it may exist in the amalgam must exercise an important bearing upon the ability of the filling to maintain the integrity of the tooth. Dr. Black determined that an amalgam mass that will flow under a pressure of fifty pounds, as measured by the instruments devised by him, would speedily end in failure when used as a filling in teeth. Furthermore, the property of flow becomes a factor in considering the *edge strength* of an amalgam. The edge of an amalgam might be sufficiently resistant to the force of mastication, but might readily flow under the same force, resulting in imperfect adaptation and failure.

Color of Amalgam.—The gradual discoloration of the surface of an amalgam filling, due to the formation of oxids and sulphids, has been a serious objection to the wide employment of this material. The silvery white of amalgam to many might not be more objectionable than the yellow of gold, but the subsequent discoloration of the surface of the amalgam filling limits its use to the posterior teeth. All attempts to prevent discoloration of the mass have ended in failure. The influence of zinc when added in the proportion of 5 per cent., and even less, has been notable in maintaining the color of amalgam, but it makes an alloy which is unfit for use as a filling material. The "facing alloy" of Dr. Flagg, which consists of silver, 40, tin, 55, and zinc, 5, and which he used only for facing purposes, was a notable example of the influence of zinc in the maintenance of color. "The addition of any of the nobler metals in sufficient quantity

to materially affect the color inevitably destroys the usefulness of the amalgam."[1]

The discoloration of the tooth substance, owing to the penetration of the salts of silver and copper, especially in improperly prepared cavities, or else in cavities filled with an amalgam of wide contraction, may result in permanent disfigurement. This cannot occur in properly prepared cavities, with the better grades of alloy upon the market, providing the filling is properly introduced. The surface of the filling may discolor—in fact, does discolor—but the salts producing the discoloration cannot stain the tooth structure.

Filling Technique.—Cavities prepared for an amalgam filling must receive the same careful attention in every particular as those prepared for gold. The rubber dam should be in position in every case in which it is possible to adjust it. Dr. Black claims that it is as impossible to make a good filling with amalgam as it is with gold, if moisture is present. The retention and resistance form of the cavity must be fully as great, if not greater, than that for gold. The outline form must be as carefully planned in relation to the principle of "extension for prevention." The convenience, or starting points, may be omitted. The cavity must have surrounding walls if the filling is to have good adaptation. Whenever a wall is missing, as in proximo-occlusal cavities, the matrix must be applied to supply the missing wall. This should be so secured in position as to allow of the necessary pressure used in packing the amalgam. This may be done by means of a ligature when the sheet metal matrix is used, or the mechanical separator may hold it in place. Care should also be exercised that the matrix is properly adjusted at the gingival margin, other-

[1] Dr. Black's "Operative Dentistry."

wise the adaptation of the filling will be imperfect in this region. It may be necessary to insert a piece of orange wood to make the matrix fit close to the gingival margin, or cotton tightly packed between the teeth will accomplish the same end.

The proper proportions of alloy and mercury are secured by weight, and rubbed together, not in the palm of the hand, as is seen so frequently, but in a glass mortar with a glass pestle, or in the rubber mortar held in the palm of the hand and rubbed with the forefinger guarded by a rubber finger-stall. The importance of securing proper proportions of alloy and mercury is one of the important factors in the making of a good filling. For the better grade alloys the proportion of mercury is somewhat in excess of the alloy, and, as Dr. Black's experiments have abundantly proven that unless just the right amount of mercury is used the amalgam mass is weakened, therefore, the custom of mixing the alloy and mercury without accurately weighing the respective amounts of each should be discontinued.

Having made the mix and thoroughly kneaded it, it is ready for insertion in the cavity. Dr. Flagg's method of inserting the amalgam was to carry an amount that would about fill the gingival region of a proximo-occlusal cavity and press it into position, after which successive pieces were adapted to the cavity walls by tapping, after the excess mercury was expressed from them by the wafering process. Dr. Black strongly advises *compression* as the best means of securing perfect adaptation, the instruments to be as large as the orifice of the cavity will admit. They should also be designed with flat faces.

After the insertion of the amalgam mass several minutes should be allowed to elapse before removing the ex-

cess and trimming down to proper form and contact. Care should be exercised in removing the matrix and separator not to break away part of the filling. This is likely to occur unless care is exercised in avoiding it. With the removal of the matrix and separator the margins are carefully inspected, especially in the gingival region. If the filling is down to proper form and adaptation the patient is dismissed for a subsequent appointment, at which time the final polishing is done, which is the same as for a gold filling.

CEMENTS

The cements include the *oxyphosphate* and *oxychlorid of zinc,* the *oxyphosphate of copper,* and the *silicates.*

Oxysulphate of Zinc.—Dr. Flagg for many years prepared and made extensive use of the *oxysulphate of zinc* for capping exposed pulps. This preparation consists of 2 parts oxid and 5 parts of the sulphate of zinc, combined, for the powder. The fluid consists of 10 grains of chlorid of zinc dissolved in a drachm of water. When used as a capping for an exposed pulp the powder and fluid are mixed together until a thick, creamy mass results, which is placed over the pulp without producing pressure. A slight hardening occurs in the mass. This, together with its astringent and antiseptic properties, exercises excellent conservative effects upon the pulp.

Oxychlorid of Zinc.—This consists of a powder, the calcined zinc oxid, into which has been incorporated a very small percentage of silex and borax to harden the final mix with the fluid. The fluid is a solution of zinc chlorid in water, half an ounce of zinc chlorid to 3 drachms of water.[1] The limitations of this material were recognized shortly after its introduction, so that,

[1] Flagg's "Plastics."

excepting for temporary use in shallow hypersensitive cavities, where its obtunding effect is desired, it is not used as a filling material. At the present time its employment is restricted to lining certain cavities and to filling root canals. Employed in vital teeth with deep cavities, it usually sets up a pulp irritation which is severe in proportion to its proximity to the pulp, and to the plasticity of the paste, allowing of free zinc chlorid. For this reason several layers of an impervious varnish should be applied as a protection to the pulp before placing the paste in position.

The irritation to the pulp resulting from the action of zinc chlorid, although more acute, is not as serious as that of phosphoric acid. From experiments conducted by Dr. Flagg in the clinic of the Philadelphia Dental College, and in his private practice, he concluded that zinc phosphate used in vital teeth appeared to be followed by devitalization much more frequently than in the use of the oxychlorid of zinc. The devitalization of the pulp in many cases following the use of zinc phosphate has been a matter of quite general observation among practitioners. Many attribute the result to the traces of arsenic found in zinc ores, forgetting that in the calcining of the powder the arsenic is certainly sublimated. Others attribute the death of the pulp, following the insertion of zinc phosphate, to the action of phosphoric acid, to which most likely it is due when surplus acid has been used in making the mix.

When intended for use as a *lining* in deep-seated cavities having weak walls, the powder and fluid of oxychlorid are placed upon the mixing slab, and sufficient powder is *slowly* incorporated into the fluid until a *putty-like* mass results. A portion of this is placed at the margin of the cavity and with pellets of cotton is

wiped against the cavity wall. The process is repeated until the cavity walls are completely covered with the material, after which it is best to fill the cavity with a temporary filling. This allows of the proper hardening of the material before placing the filling material in position. It hardens much more slowly than the oxyphosphate.

Oxyphosphate of Zinc.—The oxyphosphates similar to the other zinc plastics consist of a powder and fluid. The powder is the oxid of zinc and the fluid a solution of orthophosphoric acid. Both contain impurities, and it is to these, in some measure at least, that the uncertain behavior of the material is due after its insertion in cavities. Dr. Flagg regarded the nitrated oxid of zinc, that is, treating the oxid of zinc with nitric acid, evaporating to dryness, calcining, and pulverizing—as vastly superior to powders not so treated, and from the many experiments which Dr. Flagg conducted the superiority of the nitrated zinc oxid over all other powders was readily distinguishable. Many additions have been made to the powder in the hope of favorably affecting the final mix; the substances added have been the oxids of other metals; these additions have influenced the final mix in many ways, but apparently the solubility of zinc phosphates is as great as ever.

The fluid of zinc phosphates is prepared from glacial phosphoric acid. This acid ordinarily contains variable proportions of sodium and magnesium phosphates. These are held permanently in solution of the phosphoric acid, and, being soluble in water, must have a direct bearing upon the solubility of the mixed mass after its insertion in cavities. Dr. Flagg regarded the uncertain behavior of the fluid of zinc phosphates as precluding exact knowledge of the mixed product, and this appears to be the

position of those best informed upon the chemistry and practical utilization of zinc phosphates.

In mixing zinc phosphate the powder is added to the fluid until a stiff mass results. The amount of powder incorporated in the fluid must necessarily exert a great influence upon the behavior of the final product. We have no exact knowledge concerning the physical attributes of this material; therefore no exact rules can be formulated for the method of mixing or introduction. The tests given by Dr. Flagg[1] have been collated from extensive experimentation and comparative examinations of the material, in and out of the mouth.

First Test.—"The first test for a 'good' zinc phosphate is that it requires *decided* force to take it from the spatula." Therefore, sufficient powder should be drawn into the liquid to insure a stiff mix.

Second Test.—"The second test is that, after removal from the spatula, and after being kneaded between the thumb and forefinger, which slightly increases its plasticity, it should *not adhere* to the finger when it is pressed upon to determine this."

Third Test.—"In one or two minutes by the watch it should glaze and rebound when dropped upon wood, glass, porcelain, or marble, but not necessarily upon metal."

Fourth Test.—"In five minutes it should give a porcelain-like feel and sound when tapped gently on the edges of the lower teeth, and should have no sticky feeling when pressed between the fingers."

Fifth Test.—"In ten or fifteen minutes it should be resistant when taken between the teeth and bitten upon, and, if bitten with sufficient force, it should break with a clean, sharp fracture."

[1] Flagg's "Plastics."

Sixth Test.—"In twenty minutes it should be difficult of puncture to the point of the spatula, even with considerable force; and it should take a fine and persistent burnish."

Seventh Test.—"In thirty minutes it should have no taste, or at most an astringent, metallic taste, like that of chlorid of zinc, but not acid."

Dr. Flagg claims that in degree as a mix responds to these tests so will it make a satisfactory filling, as far as zinc phosphate can possibly make a satisfactory filling. Everything should be in readiness for the introduction of the material prior to its mixing. It is best to have the rubber dam in position, as this secures dryness, until the filling has sufficiently set, for fifteen minutes or longer, after which it should be covered with a wax or paraffin preparation melted over the filling with a heated instrument, in a way to exclude effectually the moisture from coming in contact with the filling for a day or two. A filling treated in this way will undoubtedly prove more lasting than one which is made from a careless mix, and after its introduction in a cavity is promptly exposed to the fluids of the mouth.

In no sense can zinc phosphate be classed among the permanent filling materials. They subserve a permanent function when used as linings in very large restorations, or in combination with amalgam or gold, the amalgam or gold being secured in the zinc phosphate before it has set. It may also be used in shallow cavities that are exceedingly hypersensitive, and that do not allow of proper preparation for a permanent filling. Such cavities filled with zinc phosphate for several months will be found, as a rule, quite normal and readily prepared for a permanent filling. In preparing cavities for

zinc phosphate we believe it to be good practice not to extend the margins of the cavity in the same manner as when preparing for gold or amalgam. Cavity walls that do not interfere with the thorough removal of decay may be retained. In this way so much of the surface of the filling is not exposed to the fluids of the mouth, and, therefore, is not as quickly disintegrated.

Zinc phosphate has a wide field of usefulness in filling cavities in deciduous teeth. In these cavities, especially when they first appear, it is almost impossible to prepare them in a way that will allow of the use of a permanent filling material. To do so would mean an inflictive operation. This should be avoided, which usually can be done by resorting to the use of zinc phosphate. Renewals will have to be made, but this is far better than impressing a sense of fear upon the child, which would make future operations almost impossible. (See chapter on Treatment of Deciduous Teeth.)

The Oxyphosphate of Copper.—This consists of the phosphoric acid for the liquid, and the oxid of copper, with or without additions of other metallic oxids, for the powder. This combination is used in the same manner as the zinc oxyphosphate, and is showing very good results in many cases. Its black appearance confines its use to the molar teeth, but this should not prejudice anyone against using it, as it appears to have many virtues, and in many instances far outlasts zinc phosphate. In cavities extending below the gum margin in molars many prefer this material to gutta percha.

Silicate Cement.—The silicate cements, concerning which considerable interest has recently been developed, are also oxyphosphates, but not of zinc; they are oxyphosphates of calcium, modified by the addition of other substances, notably silica alumina and other substances,

according to different formulæ. The attempt to introduce a silicate cement is not new, as our records [1] clearly show, but until recent times all such attempts have been attended with little success. Not until the appearance of the Ascher enamel could we claim to have a preparation worthy of use in a cavity of a tooth. Since the Ascher enamel was placed before the profession many other similar preparations have appeared, but they all present physical characters very much in common, such as lack of adhesiveness, shrinkage, brittleness (causing failure along the margins), and a disposition of some of these cements to blacken in the mouth. Considerable experimentation is necessary before these failings can be corrected, and the probability of their complete elimination is not viewed as a likely result by those best informed. Therefore, the extravagant claims made by many manufacturers concerning the perfection of their product should not be taken in a very strict sense, and may be compared to the enthusiastic claims frequently made for the zinc phosphate preparations, and which, up to the present writing, have not materialized. Dr. W. V. B. Ames [2] claims to have a preparation of this character which has some adhesiveness and is free of shrinkage, which would constitute a notable improvement over other preparations. Dr. Ames extends a word of caution in regard to the use of the silicate cements concerning their high thermal conductivity, which in deep-seated cavities necessitates the use of a non-conducting substance for the protection of the pulp. For this he strongly recommends the oxychlorid of zinc, as not only fulfilling the requirements for protection against thermal shock, but also having high antiseptic properties, an ad-

[1] *Dental Summary*, 1909.
[2] *Summary*, 1909.

vantageous quality considering the bland attribute of the silicates.

In mixing the silicate cements care must be taken not to use a spatula from which fine particles may be abraded, and which will become incorporated in the cement mass and discolor it, or otherwise unfavorably affect it. An agate spatula is the best instrument so far devised with which to make the mix. In mixing together the liquid and powder of some of these preparations, the increase in temperature thereby developed materially hastens the setting of the mix. In these cases chilling the glass slab upon which the mix is made will sufficiently retard the setting of the cement to allow of its easy manipulation, whereas otherwise it would set so quickly as to almost interfere with its proper introduction into the cavity. The use of heat, in the form of blasts of warm air, or heated paraffin over the surface of the filling, may be utilized in hastening the setting, after the introduction of the material in the cavity, the paraffin also protecting the filling from contact with the oral fluids.

In regard to the amount of powder that should be incorporated in a given amount of liquid, we are as much in the dark concerning the silicates as in the case of the zinc phosphates. No experiments have been performed to definitely determine this point. Furthermore, the composition of the powder, that is to say, the substances that are added as modifiers, no doubt influence the relation between liquid and powder, so that each special preparation has its special satisfying state, which allows of the use of certain proportions of liquid and powder, at which it shows best results.

The silicates are not permanent, in the sense that a gold or amalgam filling, when properly introduced, may

be considered permanent. They appear to be more permanent than the zinc phosphate fillings, and their translucent effect is decidedly more in harmony with the tooth than the opaque effect of a zinc phosphate filling. Many of the silicate fillings discolor shortly after their introduction, while others show failure from dissolution and fracture along the margins. A small percentage appear to be doing very well after two and three years' service. To what extent further experimentation may show improvement in these fillings time alone will reveal. At the present time the indications point to conservatism, with a strong probability that any radical departure from a conservative use of the silicate cements will surely end disastrously. Failure has also resulted with this material due to the neglect to give the cavity suitable retentive form. This is necessary, owing to the lack of adhesiveness of this material compared to the zinc oxyphosphate.

GUTTA PERCHA

Gutta percha as a filling material was introduced into dental practice about 1850, and, with the advent of Hill's stopping, consisted of gutta percha and oxid of zinc. Hill's stopping was a proprietary preparation, the exact composition of which was not known, but very likely resembled the preparations that have since appeared upon the market, and which are made from the crude gutta percha, into which different proportions of zinc oxid and other substances are incorporated, according to the grade prepared. Three grades are found upon the market, designated *low heat,* which softens sufficiently for use in a cavity at a temperature ranging below 200° F.; *medium heat,* which becomes plastic at a temperature ranging between 200° F. and 210° F.,

the making of which Dr. Flagg finally discarded *high heat,* which does not soften sufficiently for introduction into a cavity at less than from 216° F. to 230° F.

The high heat gutta percha, as will be seen from the degree of heat necessary to make it plastic, cannot be properly softened over boiling water. It should be heated upon a metal or porcelain plate fitted over the flame of an alcohol lamp, or else heated electrically. The heating must be done *gradually,* or the material may be ruined. It should never be softened by being exposed to the naked flame, as this will surely prove ruinous to the best preparation, and fillings made from material so softened will end in early failure.[1] Dr. Flagg expressed his conviction, founded upon an experience extending over many years, that those who denied the value of gutta percha as a permanent filling, when used where indicated, invariably mismanaged the material in heating it. Gutta percha *heat-rots* when exposed to a temperature of 240° F. As this temperature is quickly realized when the material is exposed to high heat, care is necessary to avoid heat deterioration of the material. The red gutta percha base plate prepared with the mercuric sulphid, also an excellent preparation for filling purposes, especially in deciduous teeth, softens below the temperature necessary to soften the low grade gutta percha. Therefore, it is not as resistant, but has the advantage of not becoming porous because of the presence of the insoluble mercury sulphid, its coloring agent. This preparation softens at a temperature between 150 and 180° F. The *heat test* of gutta percha stopping employed *alone* to determine the character of a certain make of gutta percha is not reliable. The proportion of

[1] Dr. Flagg's "Plastics."

zinc oxid that has been incorporated into the crude gutta percha must also be determined. It is an easy matter to raise the heat test of any gutta percha by increasing the amount of inorganics, but, as this overloads the material and makes it unfit for filling operations, it should be avoided.

The *low grade* gutta perchas, those that soften below 200° F., say at about 180° F., should not contain more than between two and three parts inorganics; the *high grades,* those that soften at about 220° F., not more than between five and six parts. To determine the character of a certain *make* of this material, the heat test, that is, the degree of heat at which it becomes plastic, should be determined, and this should bear the definite relation, as indicated above, to the proportion of admixed inorganics.

Gutta percha is indicated, firstly, in buccal or lingual cavities extending along or beneath the cervical border in bicuspids and molars, in which locations the material performs most prolonged service; secondly, in cavities which involve only the approximal surface of any tooth and where it is not deemed prudent to extend the margins for gold. Furthermore, it may be employed in any cavity in which it may be desired to defer placing a permanent filling. For introduction into a cavity gutta percha should be warmed over a suitable warmer and not exposed to a naked flame. Unless this precaution is rigidly observed the material most likely will be injured and unsuited for service. The reason for this has been previously noted. The material should be introduced piece by piece, and adapted against the parietes of the cavities by means of warmed instruments. Those best adapted for this have serrated surfaces. In smoothing the filling heated instruments should be so

directed that the material is not drawn away from the cavity margins, but toward them.

The leakage or non-leakage of gutta percha has entailed considerable discussion. Dr. W. Storer How[1] records experiments which appear to show that, when the enamel margins are properly prepared (Fig. 60) and the material packed as it should be and trimmed flush with the cavity margin when cool, it makes a moisture-tight filling. Dr. Flagg, on the other hand, maintains that gutta percha makes a leaky filling, but that the leakage does no other harm than to *cloud* the tooth.

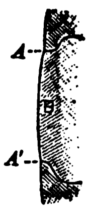

Fig. 60.

No doubt the form of the cavity and the preparation of the margins, together with the method employed in introducing the material, have a bearing upon the point at issue. Some authors[2] recommend coating the cavity walls with oil of cajuput or eucalyptus. These oils penetrate the dentin to some extent, and by slightly dissolving the surface of the gutta percha improve its adaptation. Dr. Flagg claimed that from extensive observations he was unable to detect any advantage accruing from the use of oil of cajuput or eucalyptus.

TEMPORARY STOPPING

Temporary stopping subserves such varied and useful purposes that a few words concerning it may not be out of place. It is prepared by combining red gutta percha, 4 parts, white wax, 1 part, and precipitated chalk, 4 parts. The wax is melted in a suitable ladle; to this is added the gutta percha base plate. When the two have formed a smooth thick paste the chalk is added and evenly incorporated into the mix of wax and gutta

[1] *Dental Cosmos*, 1892.
[2] Johnson's "Operative Dentistry."

percha by means of a pestle. Its mode of introduction is similar to that of gutta percha. It is non-leaky, and therefore is one of the two materials usually employed in sealing arsenic in cavities, the other being zinc phosphate. For holding treatments in teeth, for filling root canals in place of gutta percha cones, and for setting crowns and bridges in place of gutta percha, temporary stopping holds an important place among the very useful materials in a dental office.

CHAPTER XIV

DISEASES OF THE DENTAL PULP

The pathologic processes affecting the dental pulp correspond to the morbid affections of other vascular organs of the body, excepting that it is surrounded by bony tissue in a way which restricts the amount of inflammatory exudation during serious vascular disturbances, and conduces in nearly all cases to degenerative and necrotic changes.

Diseases of the dental pulp are generally associated with caries. In some few instances causes acting from within appear to induce its vital alteration. This may be noted at times in those types of individuals that appropriately belong to the *arthritic* group. It may also be noted in individuals suffering from a *nervous collapse,* and who subsequently present evidence of pulpal involvement of a tooth entirely unaffected by caries. But these are infrequent occurrences compared to the frequency with which diseases of the pulp are etiologically associated with caries.

Bearing in mind the vital dependence of the dentin upon the vitality of the filaments contained within its tubular structure, and the fact that these are prolongations of the formative cells situated at the pulpal periphery, it is evident that irritation of the tubular elements from loss of the enamel covering leads to irritation of the pulp, and if sufficiently long maintained establishes a series of vascular disturbances beginning with a con-

structive hyperemia and terminating in inflammation and degeneration. The constructive hyperemia finds its expression in the formation of secondary dentin, called dentin of repair or adventitious dentin,[1] or we may find a tubular dentinification under which the dentinal tubules or intercellular substance is increased at the expense of the fibrils or cellular. Whatever form the constructive change of the dentin may assume, it indicates the close relationship between the affections of the pulp and those of the dentin. The formation of new dentinal substance during the initial irritation of the pulp due to caries, for a time protects this organ from the invading microörganisms, but, unless therapeutic measures are employed, the microörganic life increases in potency and soon destroys the new formation of dentin, and finally involves the pulp in complete destruction. During this destructive act several morbid phenomena of the pulp may be noted.

Before considering a classification of these phenomena, with the view to ascertaining the means of making a diagnosis, as well as applying a rational therapeusis, it must be borne in mind that pain originating from pulp irritation is reflected to some other point than the source from which it arises. This has been fully expounded by Dr. Black.[2] The pulp is incapable of giving localized impressions. It is not the *tactile* organ of the tooth. The residence of the tactile corpuscles is to be found in the pericementum; hence any irritation of the pulp is usually reflected to some other part supplied with sensitive filaments from the trigeminus, or it may be sympathetically carried to some distant seat. This is an essential principle to be applied in a comprehension

[1] Hopewell Smith.
[2] "American System of Dentistry."

of the pathogenesis of the dental pulp. Under normal conditions the pulp of the average individual is not affected by temperature changes ranging from about 60° F. as the one limit to about 110° F. as the other limit. Exceptions to this at times may be noted, but they do not occur frequently enough to disturb the rule. With the loss of the protection from thermal irritation afforded by the enamel, the pulp is quickly shocked, in proportion to the loss, when substances at 60° F. are brought in contact with the tooth. If this is continued the irritation develops into pain, at first of short duration, later becoming lasting, and finally terminating in those degenerative changes under which thermal deviations induce little if any response, most likely due to degenerative changes in the walls of the blood vessels and the sensory filaments of the pulp. The shock at first sustained by the application of cold stimulates the sensory as well as the vasomotor filaments; its continuance finally induces vasomotor paralysis and permanent dilatation of the blood vessels. At this stage heat, even though slightly in excess of the temperature of the pulp, probably increases the dilatation of the blood vessels and inaugurates a continued and throbbing pain, which in its later state is frequently relieved by the application of cold water. These facts serve as a basis for determining the condition of the pulp when its physiologic aspect has passed into the pathologic through the action of one or more irritants.

Classification.—Diseases of the dental pulp may be classified as *acute* and *chronic*. But as the action of any form of irritation of the pulp is almost always accompanied by efforts of this organ to maintain the vitality of the dentin, hence we usually find calcific changes which may require separate classification, or the tissue

elements of the pulp itself may undergo departures from the normal status, necessitating a distinct division. Furthermore, when it is considered that the reparative functions of the pulp resulting in new dentin formations, if continued, finally end in atrophy and death of the pulp itself, the difficulty of exact class demarcations of diseases of the dental pulp may be comprehended. Dr. Burchard classified pulp diseases into *acute* and *chronic;* also into *destructive* and *constructive,* the acute diseases being destructive, the chronic constructive. But, while the acute diseases usually end in destruction of the pulp, so do the chronic. And, on the other hand, as the chronic diseases are usually accompanied by calcific formations, the acute diseases may also be accompanied by calcific formations.

Perhaps the following is a less confusing classification: Vascular diseases; traumatic diseases; degenerative diseases.

Vascular diseases of the pulp are those associated with alterations of its blood vessels. These are arterial or active, and venous or passive hyperemia, and simple and infective inflammation.

Traumatic diseases are those resulting from an injury, such as may arise (1) during the preparation of the cavity and the accidental penetration of the pulp chamber, inflicting more or less injury to the pulp; (2) from fracture of teeth.

Degenerative Diseases.—These have been classified by Hopewell Smith[1] as (1) *fibroid* degeneration, (2) *atrophic* degeneration, (3) *fatty* degeneration, and (4) that occurring most frequently, *calcareous* degeneration.

[1] "Patho-histology of the Teeth."

THE VASCULAR DISEASES

Arterial or Active Hyperemia

Definition.—An excess of blood in the *dilated* arteries of the pulp.

Etiology.—Arterial hyperemia may be induced by any cause competent to excite a determination of blood to the pulp. Commonly the condition is established by thermal stimulation through carious loss of the protective covering of enamel and dentin. The excessive thermal stimulation may also result through the loss of the enamel and dentin by the action of abrasion and erosion. Similarly large metallic fillings introduced without proper protection to the pulp from thermal shock by the intervention of non-conducting substances may lead to pulp hyperemia. Infected dentin may develop the disease, or an injury to the apical tissue may lead to an increase in the arterial blood supply. In rare instances we may find arterial hyperemia of the pulp reflexly induced, i. e., an arterial hyperemia of a pulp may lead to a similar condition in the pulp of another tooth through reflex action. Hopewell Smith [1] cites rheumatic affections of the jaw, also hydrargyrism, as causes of pulp hyperemia. In this relation it may be said that not sufficient attention is given to systemic factors as probable causes of the disease, and many cases present that have an internal etiological relationship which fail to recover because of the oversight of the systemic factor of the disease.

Pathology and Morbid Anatomy.—The dilatation of the arteries may be confined to a portion of the pulp, or it may occur throughout the entire pulpal mass, the latter occurring in cases of very severe hyperemia.

[1] "Patho-histology."

Note has been made of the initial *vasomotor* stimulation due to thermal shock when the pulp is deprived of its protective covering; also of the paralysis of the vasoconstrictor fibers which ultimately follows if the thermal shock is continued. This allows of an irregular dilatation of the vessel walls. Stimulation of the vasodilator fibers also leads to a dilatation of the blood vessels. But the severe grades of arterial hyperemia imply a vasoconstrictor paralysis. This is the chief pathological picture of the disease. Fig. 61 illustrates this.

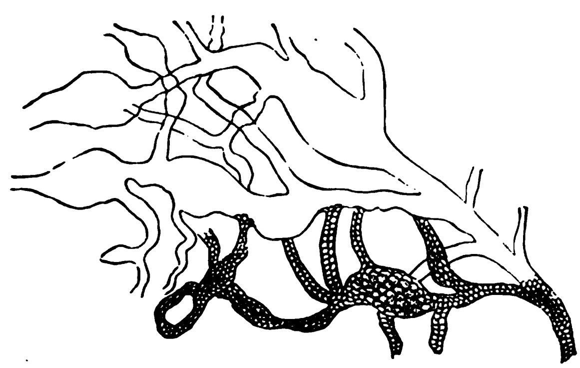

FIG. 61.—DILATED BLOOD VESSELS IN HYPEREMIA. (After Dr. Black.)

Symptoms.—The chief symptom of arterial hyperemia of the pulp is the sensation of pain, not definitely located, when cold substances are permitted to come in contact with the affected tooth. If a cavity of decay exists the presence of irritating agents, due to the carious process, may provoke a painful attack, or the entrance of sweet or acid substances may irritate the dentinal fibrils and induce pain, lasting for a moment and disappearing, or the pain may continue for twenty or thirty minutes and even longer in the very severe grades of hyperemia. Rarely, if ever, is the pain definitely located. The pain may be expressed as a momentary

shock, or as an acute neuralgic attack. The intensity of the pain, as well as the frequency of its appearance, and its duration, must be carefully noted, if the symptoms of the disease are to be made the basis of an accurate diagnosis and a rational therapeusis.

Diagnosis.—The diagnosis of arterial pulp hyperemia is made by means of the thermal test, the deductions based upon the clinical aspects of the disease as expressed by the patient, and the corroborative findings of an examination as to the existence of a carious cavity, or a large metallic filling or any other factor, local or general, competent to inaugurate the pathological changes expressive of the disease. The thermal test is made after the other findings appear to indicate the nature of the disorder, and usually leaves no doubt as to the diagnosis. The response of a normal pulp to temperature changes must be accurately known, in order that its abnormal response to these changes may be detected. Water at a temperature of 60° F., when applied to a tooth containing a normal pulp, rarely if ever calls forth more than a momentary shock. In the largest number of such cases no response is elicited. But when applied to a tooth containing a pulp in which the pathological changes indicative of arterial hyperemia have taken place, pain, more or less acute and lasting, follows. Tepid water applied to the tooth will not be followed by so marked a reaction. In this we have the final means of formulating the diagnosis, already indicated by the previous considerations as above noted.

Prognosis.—The prognosis of arterial hyperemia of the pulp for its vital preservation is favorable, if the patient presents himself before a too severe form of the disease has been established, and if we can depend upon a normal vital force necessary for recuperation.

It is manifestly unwise to attempt the conservation of a pulp, even though but slightly affected, if the patient's recuperative capacity is reduced, no matter from what cause. Such attempts usually end in failure, and may be avoided if due regard is given to the general vital state of the patient. Furthermore, it must be maintained that the teeth are end organs, not imperatively essential for the continuance of life, and that the dental pulp, although its inherent reparative capacity is great, as has been shown by Hopewell Smith, is not safeguarded from vital decadence in a way provided for more essential organs. Its anatomical relations make this obvious. Therefore it is that only under most favorable aspects can it be vitally conserved when once it has become the seat of disease.

Therapeutics.—The first essential requisite if the pulp is to be conserved is the removal of the cause. Generally, thermic shock through a metallic filling, or by reason of a cavity of decay, is etiologically associated with the disease. Or the irritating products of the carious process may be the cause of the disease. In those cases in which the condition is caused by a systemic factor, as has been discussed in considering the etiology of hyperemia, the conservative treatment may at once be abandoned, as it almost always ends in failure. With the elimination of the cause the next step in the plan of treatment is the application of one of the essential oils, preferably either cloves or cinnamon. This quickly allays any pain that may have developed in the act of removing the carious cavity mass, or the metallic filling, and, sealed in the cavity for several days, is effective in sterilizing the dentin. This is important, as the researches of several investigators have conclusively shown the deep penetration of the dentinal tubes by the micro-

organisms of caries, and, unless a penetrating and effective germicide is sealed in the cavity for several days, subsequent complications may arise from the microörganic activity within the tubes. Agents that have the power of destroying the bacteria of decay may also produce too irritating an effect upon the tubular fibrils, or upon the pulp, or may deeply discolor the dentinal tissue, and for these reasons their use may be interdicted. Cinnamon is free from any of these objections, and, while its germicidal power may not be as great as that of other agents, its use is preferred.

Camphophenique is also markedly anodyne and highly germicidal. A saturated solution of thymol in alcohol is also highly effective, possessing deep penetrating power. The formula suggested by Dr. J. P. Buckley is most excellent: Menthol, grs. xx; thymol, grs. xl; phenol., q. s. ad., ℥iij. This is mixed with precipitated calcium phosphate and sealed in the cavity. As an aid to the plan of reducing the hyperemic state of the pulp, a counterirritant may be applied to the gum over the affected tooth. Tr. iodin, capsicum, spts. of camphor, combination of two parts of aconite and one part of chloroform, used as recommended by Dr. Jack, is of value.

The therapeutics thus outlined is usually effective in reducing the hyperemia and establishing a normal condition of the pulp. This is determined by the pulpal tolerance of thermic changes within certain limits. Water within the limits of 60° F. and 110° F. when applied to the tooth should not produce a painful response. In some instances even wider deviations of temperature changes will have no effect. The hyperemic pulp gives a painful response when water at the temperatures noted above is allowed to come in contact with the tooth.

With the cure of the hyperemia a non-conducting medium is placed over the pulp to protect it from future thermal irritation. A thin wafer of temporary stopping admirably answers this purpose. Several layers of an impervious varnish, such as *rubber* or *cavitin,* each layer being allowed to dry before the succeeding one is applied, are next placed over the dentinal walls, after which a zinc phosphate filling is introduced to remain in the tooth from three to six months. This time allowance definitely determines whether the pulp has returned to a normal state.

In those cases in which pulp irritation is associated with the excessive loss of tooth substance, such as occurs in erosion and abrasion, and therapeutic effort becomes necessary to reduce the hyperemic state of the pulp, considerable difficulty may be encountered in successfully contesting the various issues that may arise. In all instances the excavations will require further preparation prior to the placing of the filling. As the dentin in these cases is usually found to be excessively hypersensitive, all our resourcefulness may be taxed before suitable cavity preparation is finally attained. Furthermore, adequate precautions must be made to guard against subsequent thermic or other irritation to the already irritated tubular fibrils. The use of the coagulants, such as phenol or silver nitrate, 50 per cent. solution, is indicated, to be followed by several layers of rubber or cavitin varnish. In some instances of erosion it may be found that a retentive cavity form cannot be made without encroaching too closely upon the pulp. Bearing in mind the extreme pulpal intolerance of compression, a thin wall of dentin is usually insufficient to support a malleted gold filling, and, although the porcelain inlay is generally employed in these loca-

tions, this cannot be regarded as being entirely free from the effect of compression, and may be followed by a hyperemia. If this appears probable it is better practice to remove the pulp prior to placing the filling.

Venous or Passive Hyperemia

Definition.—An excess of blood in the *dilated* vein of the pulp.

Etiology.—Venous hyperemia of the pulp is caused by anything which impedes the return of the blood in the pulp to the heart. With the vasomotor disturbances responsible for the arterial dilatation expressive of arterial hyperemia, it necessarily follows that if this is continued for any length of time compression of the veins of the pulp must result. This is proportionate to the arterial enlargement, and, as the outflow of blood is thus impeded, the venous apparatus of the pulp is marked by dilatations and stasis. The interference with the proper outflow of blood in the pulp may arise also from an injury to the venous vessels, or from any other condition leading to thrombosis. The formation of thrombi in the veins necessarily interferes with the proper outflow of blood, and is followed sooner or later by venous dilatations. Cardiac insufficiency, under which there is an overfullness of the veins, may also be a cause, although, as a rule, venous hyperemia follows as a result of arterial hyperemia, as noted.

Pathology and Morbid Anatomy.—The dilatation of the veins and the stasis characteristic of venous hyperemia assume a somewhat different aspect when occurring in the vessels of the pulp than when occurring in other parts. In these the exudation extending into the perivascular tissues affords some relief. In the former, owing to the bony encasement of the pulp, this phenomenon

cannot take place in the same degree. An escape of fluid may take place into the spaces surrounding the vessels, but this is necessarily very limited. Dr. Black has shown, as the accompanying figure illustrates, that the red blood cells pass through the stomata of the walls

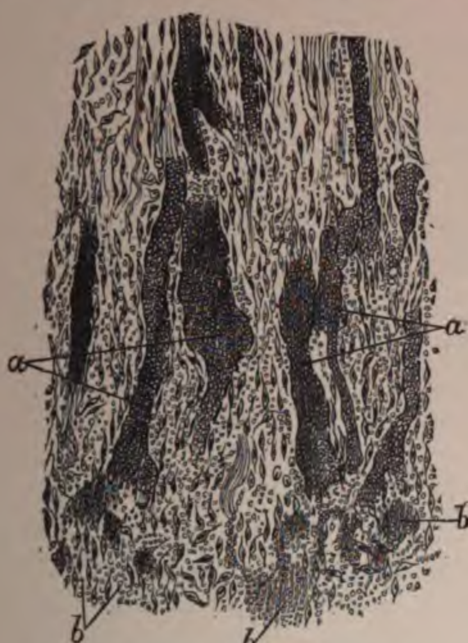

FIG. 62.—SECTION OF HYPEREMIC PULP.

Showing aneurysmal dilatation of the vessels, extravasations of blood, and red blood disks escaped apparently by diapedesis: *a*, *a*, dilated vessels; *b*, *b*, *b*, extravasated blood. Besides this, red blood disks are plentifully distributed everywhere in the neighborhood of the veins. The tooth was extracted during a paroxysm of pain. (Black.)

of the vessels. Later these may disintegrate and, liberating their hemoglobin, may deeply and variously discolor the dentin. In those cases in which the apical vessels are not entirely occluded, the exudation may take place into the periapical tissues, inducing an apical tenderness responsive to percussion upon the tooth.

Symptoms.—In venous hyperemia the pain is not as

acute as that occurring in arterial hyperemia, but persists for a greater length of time. There is a sensation of fullness about the tooth. The contact of cold does not induce the response noted in arterial hyperemia, but heat at once brings on a dull full pain, in severe cases throbbing, which usually continues for hours. In proportion to the severity of the venous hyperemia will be noted the response to heat—the severe types responding to the contact of substances but slightly in excess of the temperature of the pulp. The application of anodynes affords little or no relief, and may be taken as a sign of the existence of severe vascular disturbance.

Diagnosis.—The thermal test reveals a responsiveness to heat in proportion to the severity of the disease. Cold water has little, if any, effect. To elicit a definite response in the very mild cases of venous hyperemia, the temperature of the water used in testing may have to be raised beyond 115° F. The findings of the thermal test, together with the report of the patient as to the sensation of heaviness and fullness about the tooth, and the continuance of a dull pain, usually after heated substances have been allowed to come in contact with the tooth, clearly establish the existence of a vascular disturbance of the pulp beyond arterial hyperemia; in other words, *venous hyperemia* is present.

Prognosis.—Reviewing the pathology of the disease and the anatomical relations of the pulp, a favorable prognosis cannot be assumed.

Therapeutics.—In view of the prognosis the conservative treatment may at once be abandoned. Our first effort should be directed to the subjugation of the pain, after which the pulp is to be removed, subsequent to its devitalization, by an application of arsenic, or its anesthetization by cocain and pressure. The attempt to

control the pain through the action of the various anodynes may prove ineffective. In these instances an exposure must be made and the pulp punctured. This relieves the engorged vessels. The bleeding should be encouraged by syringing the cavity with warm water, after which any lingering pain may be quickly controlled by an application of one of the essential oils, or camphophenique, or morphin paste, or a cocain solution. The use of cocain in about 10 per cent. aqueous solution has proved most effectual in the experience of the authors. After the hemorrhage of the pulp has ceased, the anesthetic is placed upon the exposure, and by means of pressure upon a wafer of temporary stopping placed over it and maintained for two or three minutes, the pulp will be found to be completely desensitized, allowing of its immediate removal.

Acute Inflammation of the Pulp

Definition.—A vascular disturbance of the pulp presenting the definite characteristics of inflammation, namely, an exudation of coagulable fluid and marked diapedesis of the white blood cells.

Etiology.—Inflammation of the pulp may be caused by any irritant acting with sufficient intensity to produce the characteristic pathologic changes noted above. While some pathologists may maintain that the true phenomena of inflammatory changes occur only under infective irritation, it is rational to assume that similar changes may take place under other forms of irritation, and, while not quite as severe as the reactions to infective irritation, nevertheless belong to the same clinical division. An injury to the pulp or a chemical agent may so affect the pulp as to induce the changes noted in inflammation. Thermal shock, if allowed to act for a

sufficient length of time, or systemic conditions, such as gout or rheumatism, may finally induce similar results. Therefore the causes of inflammation of the pulp may be arranged in the same way as those in dealing with the phenomena occurring in other parts of the body, i. e., *infective* and *non-infective*.

Pathology and Morbid Anatomy.—Here, as elsewhere, the true pathological distinction of inflammation lies in the nature of the exudation and the marked diapedesis of the leukocytes, and the degree which these characters may reach is probably determined by the nature of the cause, bacteria and their products very likely inducing a more profound reaction than other causes. The arteries and veins are both affected, so that in the beginning we have, first, the exaltation of arterial hyperemia, its increase in function, nutrition, and sensation, quickly followed by the venous depression of function, nutrition, and sensation, and the sense of fullness accompanying venous hyperemia. These changes are quickly followed, in the acute inflammation, by the passage of the white blood cells, principally the polymorphonuclear variety, through the walls of the veins, and the outpouring of the fibrinous exudate. Owing to the unyielding surroundings of the pulp, the absence of a lymphatic system, and the constricted apical opening, it is most unlikely to find resolution taking place. In its place we have degenerative changes, indefinite calcareous deposits, and, finally, death of the pulp. If the apical vessels have not been completely occluded we may find an extension of the exudation into the apical tissues, resulting in a slight extrusion of the tooth and consequent tenderness upon pressure.

Some writers[1] claim that inflammation of the pulp

[1] Burchard's "Pathology."

may be followed by recovery. With this we cannot concur, if presented in anything but a sense of vaguest possibility. The anatomy and histology of the pulp show most conclusively the improbability of its recovery when the seat of such changes as are here considered, and this is fully corroborated by clinical experience. If the cause producing these changes, in a certain area of the pulp, is not removed, other portions of the organ become sim-

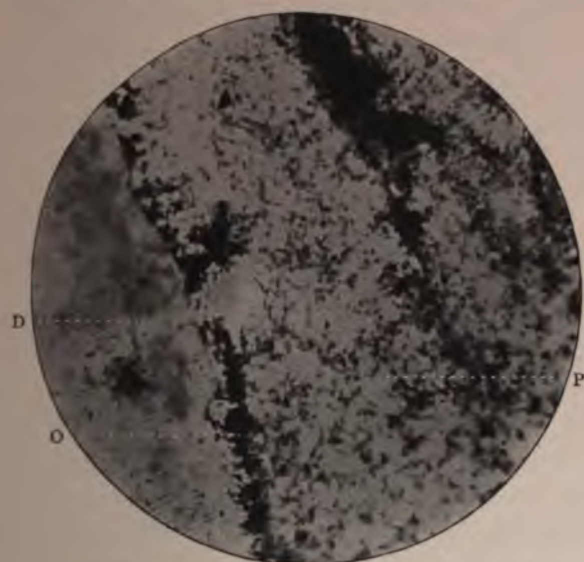

FIG. 63.—ACUTE INFLAMMATION OF THE PULP.
Magnified 80 times. D, Dentine; P, Pulp tissue crowded with inflammatory products; O, Odontoblasts. (Hopewell-Smith.)

ilarly affected, i. e., inflammatory foci appear. These consist, according to Hopewell Smith, of proliferated connective tissue cells (macrophages), pulp cells, and mono- or polynuclear leukocytes, which have escaped from the numerous enlarged capillaries, all having been attracted together by a kind of positive chemotaxis. "Later these may suppurate and form localized abscesses."

Symptoms.—The pathological consideration of inflammation has disclosed it to be essentially a series of hyperemic changes with severe migration of the leukocytes and exudation of coagulable lymph, and presenting certain forms of terminations. In considering the symptoms our interest centers mainly in the series of hyperemic changes. Under the action upon the pulp of one of the various forms of irritants, discussed under the etiology of inflammation, an initial arterial hyperemia is established, the paroxysms of pain rapidly growing severe and more frequent. Next the veins are affected with the sense of pressure and fullness characterizing venous hyperemia. This becomes intensified as the leukocytes and fluid contents of the vessels pass through the vessel walls into the perivascular tissues, and if no exposure exists to give relief to the pressure of the exudate a heavy, continuous, throbbing pain results, which may persist for hours. The pain is usually reflected to some other part. With the extension of the hyperemia into the pericementum localization of pain is developed when pressure is made upon the affected tooth. The recumbent position usually intensifies the pain, or may be followed by a severe paroxysmal attack in the quiescent but inflamed pulp, owing to the pressure from the increased flow of blood in the reclining position. Heat invariably intensifies the pain, or it may be the means of ushering in a severe paroxysmal attack. Cold is not so likely to prove painful; in fact, in many instances it appears to diminish the acute pain. This is especially so in the suppurative forms of pulp inflammation.

Diagnosis. As a rule little difficulty is experienced in differentiating the severer forms of vascular disturbances of the pulp from the one form, namely, arterial hyperemia, in which alone the conservative method is

practiced with any degree of success. The character of the pain, its duration, the immediate response to heat, the lessened response to cold with the possible relief from pain in the acute form of pulpitis when cold water is held against the affected tooth, leave little room for doubt as to the nature of the disease. This evidence may be further strengthened by the existence of an exposed pulp, or carious products beneath a filling, or the history may reveal an irritated pulp of long standing, with a development of severer painful manifestations from which, through neglect, no relief was sought until the still severer manifestations of inflammation presented.

Prognosis.—This is always unfavorable.

Therapeutics.—In view of the prognosis the plan of treatment is to control the pain and subsequently remove the pulp. If an exposure of the pulp exists, but little difficulty will be encountered in controlling the pain. If an application of cinnamon, cloves, thymol, menthol, or the combination of menthol, thymol, and phenol (Buckley), or of morphin paste, is not promptly followed by relief, the pulp is to be punctured. This relieves the engorged vessels, and when, after the bleeding has ceased, one or more of the above anodynes are applied, the pain is usually controlled. In many cases, when this stage has been reached, the pulp may be removed at the same sitting under cocain and pressure. If, however, it is decided to devitalize the pulp by means of arsenic, in such cases it is preferable to seal a pledget of cotton carrying one of the above anodynes in the cavity for twenty-four or forty-eight hours, and if no painful symptoms have recurred the arsenic may then be applied.

In those cases in which no exposure exists, as a rule,

considerable difficulty attends all attempts to allay the pain and remove the pulp. Every effort to uncover the pulp in order that it may be punctured usually proves too painful for the patient's endurance, owing to the heat created by the friction of the bur and the almost immediate and intense reaction of an inflamed pulp to heat. In these cases it is necessary to administer nitrous oxid, and while under its anesthetic effect both the exposure and puncture can be made painlessly. This course of treatment should be suggested without delay, otherwise the patient, wearied by much suffering, may insist upon removal of the tooth. With the uncovering and puncturing of the pulp and the application of the aforementioned anodynes, prompt relief usually follows. The treatment that follows is as priorly noted. Under favorable conditions, as may obtain in single-rooted teeth, the entire pulp may be removed while the patient is under the influence of the anesthetic. Counterirritants applied to the gum are only of value after the pulp has been depleted; prior to this they possess little value.

Internal medication may be indicated at any stage of the disease as the only means of arresting the pain, which, if not controlled, would terminate in the loss of the tooth. Internal medication should not be indulged without positive knowledge as to the existence of idiosyncrasy, habit, or any other condition that might contraindicate the use of certain drugs, and this knowledge is to be obtained through consultation with the patient's physician. In the writer's experience 5 grains of aspirin, repeated in two hours, has proved eminently serviceable. Or the following:

℞	Phenacetin	grs. x
	Acetanilin	grs. x
	Strychnin sulph.	gr. 1/8

Divide into 4 powders, one to be taken every 2 hours. Or:

Codein sulph.	gr. j
Acetanilin	grs. x

To be divided into 4 powders, one to be taken every 2 hours.

With the relief obtained by the use of one of the foregoing prescriptions, the next plan of the treatment is to expose the pulp, if no exposure exists, by placing the patient under nitrous oxid, deplete, and finally remove the pulp as previously discussed; or, if this should be inadvisable, an arsenical application must be made, or by means of cocain and pressure the pulp may finally be removed.

Chronic Inflammation of the Pulp

This at times follows the acute variety, which it resembles in its pathologic characters.

Etiology.—In a general way the causes are similar to those producing the acute variety, but whether they act against strong resistive conditions of the pulp, or whether the acting cause is less violent, or whether systemic factors,[1] such as gout and hydrargyrism, have a bearing in the development of chronic inflammation, is not clearly determined.

Pathology and Morbid Anatomy.—As previously stated, the pathologic characters are similar to those occurring in the acute form. Hopewell-Smith reports that in nearly all cases of chronic inflammation large masses of calcoglobulin nodules appear in the pulp, the formation of which may continue until the entire pulp is converted into a hard calcareous mass. The vessel walls of the pulp lose their *tonus* and remain in a state

[1] Hopewell-Smith.

of permanent dilatation. In cases of exposure productive changes may take place, leading to the enlargement of the pulp and its extension into the cavity of decay which it may completely occupy. This is known as *fungous pulp, polypus of the pulp,* or *hyperplasia of the pulp.* Or pyogenic infection may take place and the suppurative process may gradually destroy the entire pulp without acute manifestations.

Diagnosis.—Chronic inflammation of the pulp is easily distinguished by the history and the response to the thermal test, which resembles that of the acute form. In chronic inflammation the pulp does not react as decisively to heat as it does in the acute variety; in fact, all its features are subdued. But the findings of an examination, the history of the case, and the thermal test easily establish the *diagnosis.*

Therapeutics.—The principle of the treatment corresponds to that of the acute variety. If pus is present either upon the surface of the pulp or in its body this should be removed; if pain exists it should be allayed, after which the pulp is to be removed, either by means of arsenic or cocain and pressure.

Chronic Hypertrophic Pulpitis—Pulp Polypus—Hyperplasia of the Pulp

These are synonymous terms indicating a chronic productive inflammation resulting in an enlargement of the pulp and its extrusion through the orifice of an exposure. The enlargement may continue until the carious cavity is filled with the fungoid mass, and may extend beyond the margins of the cavity. In this form it closely resembles hypertrophy of the gum, from which, however, it can easily be diagnosed.

Etiology.—Fungus pulp appears to be due to the irritation of the sharp margins of the pulp cavity, which may become resorbed as the organ increases in size. The pulp is the seat of a chronic inflammation associated with an exposure. The distention caused by the inflammatory changes leads to an impingement upon the margins of the exposure, and establishes a continued irritation re-

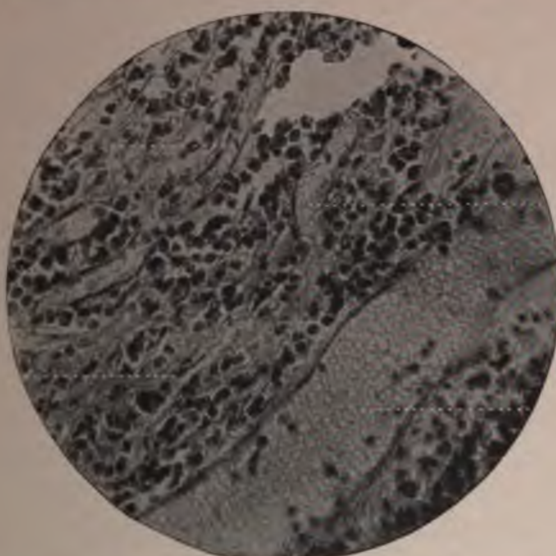

FIG. 64.—CHRONIC INFLAMMATION OF THE PULP, WITH HYPERPLASIA. (Hopewell-Smith.)

sulting in a productive inflammation and an increase in the size of the pulp.

Pathology and Morbid Anatomy.—The irritation of the margins of the exposure against which the pulp presses results in a proliferation of the cells of the inflamed area and forms a mass of granulation tissue, which later develops into a framework of fibrous tissue, and as the irritation persists new granulation cells appear, supported by the fibrous framework. The mass also

contains blood vessels which develop in all repair areas by the extension of the capillaries. The explanation for the covering of squamous epithelium found upon the surface of the hypertrophic mass, which normally contain

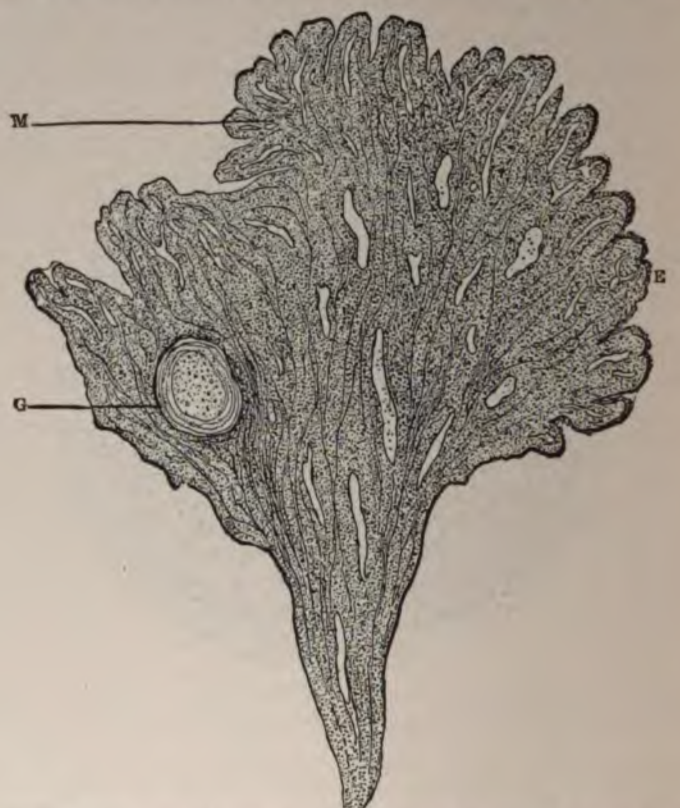

FIG. 65.—HYPERPLASTIC MYXOMATOUS PULP, WHICH FILLED A CARIOUS CAVITY: M, lobules made up of papillæ of a myxomatous structure, rich in capillary and venous blood vessels; G, calcareous globule; E, epithelial cover of papillæ. x 10. (Bödecker.)

no epithelial cells, is, according to Hopewell-Smith,[1] that it is derived from the mucous membrane of the cheek transplanted to the hypertrophic pulp during mas-

[1] "Patho-histology of the Teeth."

tication, and grows after the manner of skin-grafting. Dr. Black explained its presence as a process of skin-grafting, naming the gums as the source from which the epithelial cells arise. But whatever its origin, it must be considered as an attempt at *healing,*[1] and the fact that pulps with this epithelial covering may remain in a carious cavity for a long time without annoyance to the patient appears to bear this out. Subsequently these growths may undergo degenerative changes; both the fatty and calcareous have been noted; and finally suppuration and gangrene may take place.

Symptoms.—Pulp hyperplasia belongs to the chronic inflammations; its symptoms, therefore, correspond to those of the other forms of these pathological manifestations, modified by its patho-histological features. The fungoid mass contains no nerve fibers, so that pressure made upon the growth is not painful, although pain may result from pressure upon the nerve fibers of the pulp. The severity of the reflex pains and responses to heat and cold are dependent upon the degree of vitality still residing in the nerve fibers of the pulp, and the protection which the new growth may afford the still sentient fibers from thermal and other irritation. While the growth may afford protection to the pulp from thermal irritation, it may also by the *pressure of contiguity* cause pain, and this may become severely increased when anything presses upon the growth itself. The symptom that usually impresses the patient most strongly is the bleeding of the hypertrophic mass which results in many cases from the slightest pressure, and where the pain is not sufficiently severe, or where the size of the growth is not the means of inducing the patient to consult the dentist, the hemorrhage usually is the means.

[1] "Patho-histology of the Teeth."

Diagnosis.—If the mass does not extend beyond the cavity margins no difficulty exists in making the diagnosis; if, however, it does so extend, care must be exercised in differentiating between a pulp or gum hypertrophy, the only condition with which it may be confounded. In such cases pressure carefully applied in proportion to its excitation of pain should be made with a rope of cotton steeped in an anodyne solution, or gutta percha may be used, and the mass pressed beyond the cavity margins, or perforation, or else toward the pulp canal. This usually takes from 24 to 48 hours, and longer where a hypertrophic gum has extended through a perforation in the side of the root, but suffices to establish the diagnosis.

Therapeutics.—The diagnosis being established, the pulp is to be removed, either after an arsenical application has devitalized it, or by means of cocain and pressure.

Suppuration of the Pulp

Definition.—The formation of pus upon the surface, or within the tissues of the pulp. In the first instance the condition is defined as *ulceration;* in the second as *abscess* of the pulp.

Etiology.—Without pyogenic infection a suppurative condition cannot be inaugurated; therefore the immediate cause of pulp suppuration lies in the entrance of pyogenic germs into the pulp. This may occur, as shown by Arkövy, without the existence of an exposure; in other words, pyogenic organisms may gain entrance to the pulp through a layer of unaffected dentin. Even secondary dentin may be penetrated by microörganisms. This has been shown by Goadby. In fact, the pulp may become infected through the circulation. In no other

way can those cases be explained wherein pulps have been the center of moist gangrene and suppurative changes with every other portion of the tooth in perfect

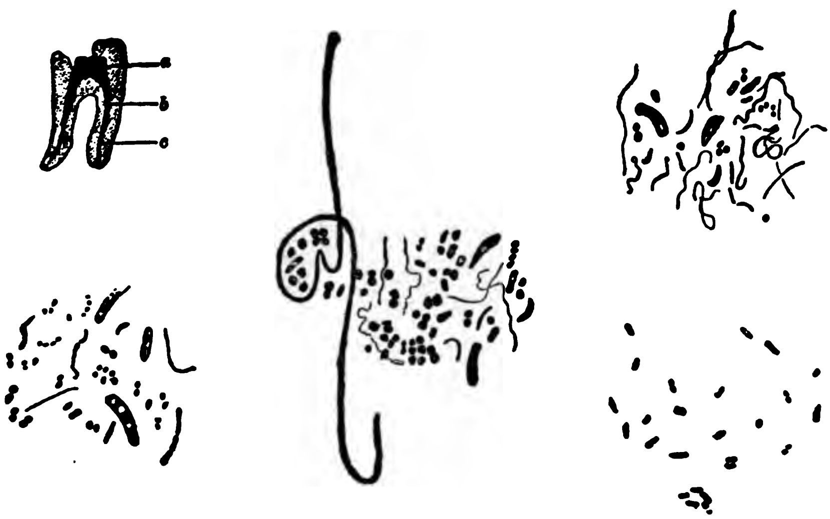

FIG. 66.—MICROÖRGANISMS FOUND IN CULTURES FROM GANGRENOUS PULP. (Miller.)

condition. Fig. 66 shows the various organisms found by Miller in a suppurating pulp.

Pathology and Morbid Anatomy.—With the entrance of the pyogenic organisms to the pulp the destruction of its tissues takes place, as noted above, either as an ulcerative process, the germs passing between the pulp and its surrounding wall, or within the substance of the pulp, extending along the walls of the blood vessels and into the perivascular tissues. Evidences of inflammatory reaction may be noted in the presence of the inflammatory exudate in the perivascular tissue, also of the leukocytes, proliferated connective tissue cells, and other cells that appear to be attracted together by a chemotactic process. The destroyed tissues show evidence of the further changes of putrefaction in the putrid

odor which can be detected in many cases, indicating the presence of certain end products of decomposition. If the putrefactive process has affected the entire pulp the apical pericementum in many cases becomes hyperemic, representing the first stage of the irritating effects of the infective material in the canal. Hopewell-Smith also calls attention to a large form of dentinal deposit that characterizes acute suppurative conditions of the pulp. This is also found in chronic forms of inflammations. That various forms of calcific changes accompany the acute and chronic inflammatory changes of the pulp is quite clear, considering how general is their presence in all hyperemic changes of the pulp.

Symptoms.—The symptoms of either ulceration or *abscess* of the pulp depend upon whether the process is acute or chronic. The acute form of either process is essentially an acute inflammation with the symptomatology of the latter disease, perhaps intensified by the added phenomenon of pus formation. The pain is reflex, intense, and throbbing, with an immediate response to heat, and a disposition to relief from cold. The painful paroxysms may continue for hours. In the chronic form of either *ulceration* or *abscess* of the pulp the symptoms are those of chronic inflammation, not of the productive but of the destructive variety. The pain is reflex, rarely grows acute, and the responses to heat and cold are delayed; in fact, if the entire pulp has been destroyed no response is forthcoming. In multirooted teeth, where the separate pulp filaments are in different stages of the infective process, cold may elicit a painful response in the filament in the first stages of vascular disturbance. The second may give a painful response to heat, showing it to be in the more advanced stage of disturbance, while, owing to the complete destruction of the

third filament and its putrefactive decomposition, the pericementum in this region may be affected, indicated by the pain when pressure is made upon the particular portion of the tooth.

Diagnosis.—Abscess or ulceration of the pulp is diagnosed by the history of the case and the response to the thermal test. The history is that of chronic inflammation, and the thermal test reveals an immediate response to heat, with little, if any, response to cold, and a disposition to relief from a paroxysmal attack when cold water is held against the tooth. This disposition is more in evidence in the acute stages of either disease. The presence of pus in the pulp can only be definitely determined when the organ is punctured and the pus exudes as a minute bead. Or, in some instances, under the effect of cocain, the pulp may be removed and pus detected upon its surface. Burchard [1] records instances in which secondary dentin was formed in one filament while an abscess occurred in the other. In other instances attempts at circumvallation of the dead areas may take place with calcareous deposits (Fig. 67). In these cases an accurate diagnosis is reached with difficulty.

Prognosis.—As in all inflammatory diseases of the pulp, the pulp ultimately dies. With the added feature of pyogenic infection, which the conditions under present consideration indicate, recovery cannot appear as a tenable proposition.

Therapeutics.—The acute cases must be relieved of the presence of pus, if this is possible, followed by the application of the various anodynes considered under *acute inflammation,* for the control of the pain. The escape of the pus is induced by puncturing the pulp. Usu-

[1] Burchard's "Pathology and Therapeutics."

ally this also affords relief to the engorged vessels. W
the cessation of the hemorrhage and the control

Fig. 67.—Chronic Suppurative Pulpitis Terminating in Calcification
The Pus and Atrophy of the Pulp.

A^1, larger abscess, filled with calcified pus; A^2, abscess at the periphery of the pu
A^3, A^3, small longitudinal abscesses, all calcified; N, calcified nerve bunc
C, C, calcareous depositions in the fibrous pulp tissue; P, P, pigment clust
from previous hemorrhage. x 10. (Bödecker.)

the pain, the attempt may be made to remove the pu
under cocain and pressure. If, however, such attem

is followed by a development of pain, it is best to place upon the exposure an anodyne—the thymol, menthol, and phenol mixture (Buckley) acts admirably—to be sealed in the cavity for 24 hours. Arsenic may then be applied for the devitalization of the pulp. In the chronic cases, as a rule, the pulp can be removed under cocain and pressure.

Gangrene of the Pulp

Definition.—Death of the pulp following nutritional disturbances. Both the *dry* and *moist* gangrene have been noted occurring in the pulp.

Dry Gangrene of the Pulp

Definition.—Death of the pulp following nutritional disturbances, and its further change into a dried, atrophied mass.

Etiology.—Dry gangrene of the pulp may be caused by any factor competent to impair the nutritive balance of the pulp, ending in its death, and the subsequent removal of its contained moisture, ending in its being dried and shriveled. This condition may be brought about through an injury to the arterial vessels in the apical region, leading to thrombosis and the death of the pulp, owing to the loss of its nutrition. The moisture is drained off on the venous side, completely drying the pulp. Bacteria are excluded, or, if present, fail to effect a putrefying process, because of the lack of moisture. A similar state of the pulp may follow the action of chemical agents used in cappings, or linings of cavity walls. Frequent examples of this have been found following the use of oxychlorid of zinc linings and in the use of mummifying pastes.

Pathology and Morbid Anatomy.—The diminished nutrition leads to a shrinkage in size of the cells of the pulps. The fibrous elements may increase until the pulp is entirely converted into a fibrous structure in which no cell elements can be found, and the normal arrangement of the tissues of the pulp is completely lost. The odontoblasts likewise have lost their cell characters, and remain as irregular fibrous forms; in other words, the pulp is in a state of complete fibroid degeneration.

Symptoms.—Dry gangrene of the pulp rarely occurs; there are no defined symptoms for its diagnosis. The tooth retains its color. Under the light of an electric mouth lamp a degree of opacity may be discernible. The thermal test is negative. The dentin is devoid of sensation, and this fact usually develops the suspicion of the death of the pulp. Cautiously the bur is directed toward the pulp, and with the entrance into its cavity it is found as a dried, tough, and shriveled mass.

Diagnosis.—As previously stated, no definite symptoms exist whereby the diagnosis of dry gangrene of the pulp can be made. The insensibility of the dentin and the negative response to extremes of heat and cold indicate the death of the pulp, but the discovery of the condition of dry gangrene can be made only after the exposure and removal of the pulp.

Therapeutics.—The death of the pulp being positively determined, its removal should be effected under strictest aseptic precautions. The dam should be placed over the tooth, the cavity flooded with suitable germicides, a saturated solution of thymol in alcohol answers the purpose well. This is allowed to dry slowly, after which the pulp is removed and the canal filled. (See Root Filling.) As a rule no complications follow if suitable precautions have been taken. However, it is prudent to delay

the insertion of the permanent filling for several weeks in anticipation of a possible apical irritation, which may, although most unlikely, require the removal of the filling for its successful treatment.

Moist Gangrene of the Pulp (Pulpitis Gangrenosa Chronica)

Definition.—Death of the pulp and its subsequent putrefactive dissolution.

Etiology.—Moist gangrene of the pulp is immediately caused by the action of saprophytic bacteria in necrosed areas of pulp tissue. The pulp, being acted upon by some cause to disturb its nutrition, soon loses its vital standard, degenerates, and affords a suitable medium for the action of putrefactive bacteria. This may occur in teeth without cavity or filling, in which instances the bacteria gain entrance to the pulp either through the circulation or through defective enamel formations, or possibly through the cementum and dentin at the neck of the tooth. By far the greatest number of cases of moist gangrene occur in filled teeth, in which infected dentin contains the agents of decomposition, or in which the pulp has not been completely removed, and which later on is acted upon by bacteria remaining in the canal. In an examination of 43 cases of chronic apical abscess, pulp gangrene, etc., Arkövy [1] found the *Bacillus gangrenæ pulpæ* present in 41; the *S. pyogenes aureus* in 15; *S. pyogenes albus* in 8; *S. pyogenes citreus* in 2; *S. pyogenes* in 10, and *B. pyocyaneus* in 4. Healthy pulps inoculated with the *bacillus gangrenæ pulpæ* in pure culture produced total gangrene without suppuration, which satisfactorily explains the death of pulps and

[1] Burchard's "Pathology."

the condition of moist gangrene taking place under fillings.

Pathology and Morbid Anatomy.—The mixed invasion of the pulp is followed by the complete dissolution of the tissue elements of the pulp in the final stages, and the formation of a series of chemical substances presenting varying degrees of chemical complexities; peptones are first formed, followed by the highly toxic ammonia compounds, the ptomaines (putrescin and cadaverin), leucin, tyrosin, and the methyl, ethyl, and propyl compounds; next such products as indol, phenol, and cresol; and finally the end products of hydrogen sulphid, ammonia, carbon dioxid, and water. The accompanying figure diagrammatically illustrates the location of these substances in cases in which the infection has taken place through a carious cavity. The appearance of the pulp is an index to the degree of decomposition that has taken place. In the final stages the tissue elements of the pulp are totally destroyed and the contents of the canal is a fluid containing some of the aforementioned substances. Previous to this some of the tissue elements of the pulp are still bound together, so that what remains of the organ may be removed with the broach.

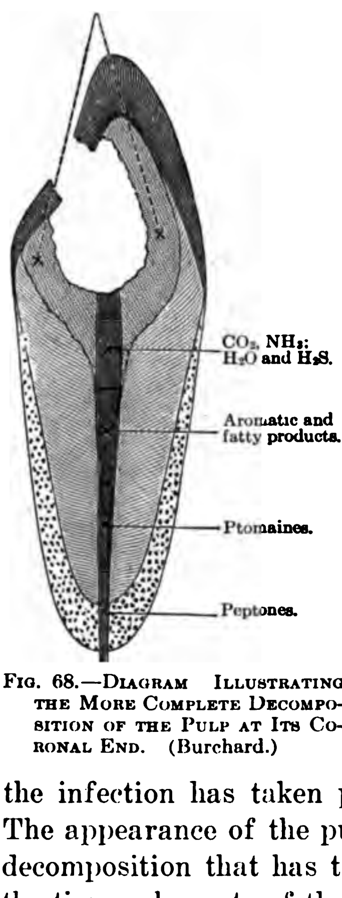

FIG. 68.—DIAGRAM ILLUSTRATING THE MORE COMPLETE DECOMPOSITION OF THE PULP AT ITS CORONAL END. (Burchard.)

Symptoms.—In those cases in which the entire pulp tissue has been affected heat and cold, as well as other tests for pulp vitality, prove negative. In advanced cases, that is, with considerable gaseous accumulation in the canal, heat provokes a response proportionate to the pressure created by the expansion of the gases. In multirooted teeth a more or less confusing state may arise in directing heat and cold against the tooth, if a gangrenous pulp should lie in one canal while the other filaments still preserve degrees of vitality. In these cases both the heat and cold may provoke painful responses, together with the tenderness manifested when pressure is made upon the tooth in the region of the root with the gangrenous pulp, due to apical irritation. A confusing combination of symptoms may present unless it is clearly remembered that the septic material in the canal containing the gangrenous pulp irritates the apical pericementum, which the heat and pressure intensify, while the cold affects the vital filaments contained in the other roots. The discoloration of the tooth bears additional evidence of pulp decomposition. This may exist in all the varying shades produced by ferrous sulphid, formed by the hydrogen sulphid combining with the iron of the hemoglobin of the red blood cells, staining the dentin. (Dr. Buckley regards the discoloration as being due to the staining effect of ferric hydroxid.) In drilling for an opening into the canals but little progress is necessary before the escape of the mephitic gases force themselves upon our senses. At times patients will complain of an obnoxious taste or odor emanating from a certain tooth containing a large filling, which very likely is due to the escape of these gases owing to a leaky filling.

Diagnosis.—The discoloration of the tooth, the re-

sponse to heat, the tenderness upon pressure at some portion of the tooth, and the evidence of the putrefactive condition disclosed upon opening the tooth conclusively point to the diagnosis of *moist gangrene.*

Therapeutics.—The recognition of the character of the canal contents imperatively calls forth the use of such agents as will effectively destroy the various substances formed in the serial decomposition of the putrefactive process. These substances have been considered under the pathology of the disease. A vitally important point bearing upon the conservation of the tooth, to be fully in the mind of the operator in treating these conditions, is the danger to be avoided of forcing any of the highly infective material through the apical opening. This usually occurs when the broach is passed into the canal in the effort to remove its contents, prior to the destruction of the infective material contained in the canal; therefore, an essential step in the treatment of putrescent pulps is the destruction of the dangerous compounds formed by the putrefactive process, by means of some agent or combination of agents, sealed in the cavity.

The tooth should be placed under the dam, the cavity sterilized with a 5 or 10 per cent. solution of formalin, dried, and flooded with full strength alcohol, again dried, and free openings made into the canals. Over each opening a pledget of cotton is placed saturated with the formalin-cresol mixture (equal parts), introduced by Dr. Buckley, by whom it is claimed [1] that the formalin unites with the ammonia, producing the solid *uratropin,* with the hydrogen sulphid, forming methyl alcohol and sulphur. According to other authorities, formaldehyde unites with basic ptomaines, forming inodorous com-

[1] J. P. Buckley, Johnson's "Operative Dentistry."

pounds. The cresol is added to subdue, through its anodyne quality, the irritating effect of formaldehyde, and to bring about the chemical destruction of the fatty compounds found in putrescent conditions, and to aid in the plan of sterilization. It is many times more powerful as a disinfectant than phenol. This formo-cresol mixture should be *hermetically sealed* for two or three days over the canal with a quick-setting cement, according to the recommendation of Dr. Buckley, and *pressure must be avoided.* The patient is instructed to return at the expiration of the two or three days, when the tooth is again placed under the dam, sterilized, and the dressing removed. If odor indicative of putrescence is found, or if effervescence takes place in testing with a solution of hydrogen dioxid, the canals should be flooded with alcohol, dried, and the formo-cresol mixture placed in each canal upon cotton, and the cavity again sealed. The patient is again instructed to return after two or three days, at which time all evidence of putrescence will have disappeared. Dr. Buckley advises at this stage a modification of the original formula of equal parts of formalin and cresol, by adding one or two minims of cresol to two minims of the original formula as a dressing for the canal. It is best to allow this to remain for about three days, by which time the entire dentinal structure will be sterilized.

The claim of complete dentinal sterilization has not been substantiated. From experiments conducted by Dr. Jules A. Vuilleumier, reported in *The Dental Era,* 1910, it is shown that pathogenic organisms are found in the canal after the use of the formo-cresol, and, while admitting the clinical value of the combined use of these agents, advises more frequent applications than in the plan of treatment given by Dr. Buckley, in the hope of

effecting a sterile state of the dentinal tissues. In this respect Dr. Mayrhofer's experiments, reviewed in the *Cosmos* for January and November, 1909, and later April, 1911, which antedate those of Dr. Vuilleumier, also show that the plan of treatment as advised by Buckley does not result in complete sterilization of the canals. Dr. Mayrhofer's experiments appear to show better results in the use of Balsam of Peru.

In those cases in which the pulp of one canal is in a state of moist gangrene, while the pulp of a second or third canal of the tooth gives evidence of vitality, the formo-cresol mixture should not be allowed to come in contact with the vital pulp, as the irritating property of formalin will provoke severe pain in the still vital filament. It is best in these instances to make an application of an anodyne to the vital pulp, cover this with zinc phosphate, or temporary stopping, and then proceed with the treatment of the gangrenous pulp as given; or the vital filament may be removed under cocain and pressure at the first sitting.

The formo-cresol method of treating putrescent conditions, in the writers' experience, is superior to any heretofore introduced. It is more easily utilized than the sodium dioxid, or the Schrier's alloy of metallic sodium and potassium plan of treatment, and is equally if not more effective.

TRAUMATIC DISEASES OF THE PULP

The histology of pulps injured either through trauma or by the action of caries has been carefully studied by Hopewell-Smith. His researches include five divisions: First, when a minute area of pulp tissue has been injured; second, when a large surface has been traumatically exposed; third, ordinary exposure of the pulp by

the action of caries; fourth, fracture of teeth with or without impaction of the fragments; fifth, in cases of non-exposure of the pulp. For our purpose we are only concerned with those injuries which result during the preparation of a cavity, in the act of which the pulp is exposed, and bleeding has taken place, and in those which result from fracture of the tooth with an associated pulp lesion.

Injury of the Pulp by Means of the Bur or Other Instrument During Excavation of the Cavity

Pathology and Morbid Anatomy.—The penetration of the small vessels of the pulp is followed by a hemorrhage, which usually is readily arrested. The deeper vessels are dilated and stasis occurs. This is followed by an escape of the leukocytes and coagulable lymph from the blood vessels into the perivascular tissues. The phenomena resembling a simple traumatic inflammation. The connective tissue elements proliferate, the coagulated lymph is removed, and repair cells (leukocytes) appear, and with the formation of new capillaries by extension of the old vessels the blood supply is brought to the repair area and a cicatrix is formed. This phenomena of cicatrix formation can only take place in the absence of *infection.*

Prognosis.—If the injury is not severe and strict aseptic precautions have been maintained in the cavity, if no infection of the pulp has occurred during the act of injury, and if the pulp has not been irritated by the use of powerful chemical agents, either to arrest the hemorrhage or in the endeavor to maintain asepsis, the prognosis is favorable.

Therapeutics.—This implies the avoidance of the use

of irritating agents, as previously noted, which would interfere with the process of repair; therefore, the use of capping agents containing irritating chemical agents immediately after the bleeding has ceased is not conducive to conservative ends, and is one reason why many pulps die that have been injured during preparation of the cavity, and that have been immediately capped upon cessation of the hemorrhage. A better plan is to remove the blood with a 25 per cent. alcoholic solution in sterile water. Place a concave disk over the exposure, and after thoroughly varnishing the cavity walls with an impervious varnish, fill the cavity with zinc phosphate. This is to remain in place for from three to six months, when the pulp is tested for its vitality, and, if confirmative, a permanent filling may be introduced, great care being exercised not to produce pressure upon the pulp.

Injury of the Pulp Resulting from Fracture of the Crown

Pathology and Morbid Anatomy.—Hopewell-Smith[1] reports a case in which the pulp was prepared for examination twelve hours after the accident. In this specimen the pulp was found crowded with emigrated leukocytes and proliferating connective tissue cells. The blood vessels were hyperemic and in certain portions of the pulp thrombosis had taken place. The escape of the exudate through the vessel walls had compressed the odontoblasts against the dentinal walls. In specimens examined seven days after the lesion had occurred evidence of the deposition of calco-globulin was found in different parts of the pulp. This same author notes that the laying

[1] Hopewell Smith, "Patho-histology of the Teeth."

down of calcific material is a "favorite method of repair on the part of the pulp." Just how these deposits take place is not determined. Dr. Black[1] compares them to the phleboliths found in varicose veins, as the dilated veins contain the factors necessary for the production of these calcific masses, viz., the retained carbonic acid in the presence of albumen and lime salts. In another case of fracture[2] the pulp became finally calcified, showing that it had completely healed its lesion. An interesting instance of union of fragments of a fractured tooth is that of Storer Bennett's (*Trans.* Odonto. Soc. of Great Britain, April, 1896). His description of the case is given:

"A case in which, hemorrhage having taken place, a natural capping of the exposed pulp occurred, somewhat similarly to the way a wound heals under a scab. Blood was poured out between the fragments, organization took place, numerous blood vessels were produced, and ultimately calcification occurred; and, eventually, if it had been left long enough, the whole of the space would probably have been filled up with calcific material more or less resembling bone, or bone and cementum together." Fig. 69 illustrates the case.

Prognosis.—Injuries of the pulp following fractures are almost always followed by inflammatory reactions, and, although evidences of repair are found, and in the one case cited complete calcification had taken place, the prognosis is unfavorable.

Therapeutics.—If severe pain follows the fracture, efforts are to be made to subdue this by the use of the various anodynes. If these fail, after persistent effort, the pulp should be removed under *nitrous oxid.* In this

[1] "American System of Dentistry."
[2] Hopewell-Smith.

manner the patient may be saved considerable suffe
and the effort to establish a comfortable state ma
considerably expedited. In many cases pulp extirp
is followed by considerable bleeding, and the form
of a blood clot in the apical region is likely to ind

FIG. 69.—SAGITTAL SECTION SHOWING THE PARTS.

E, Enamel; D, Dentine; P, Pulp cavity; O, New ossified material which act a definitive callus. (Hopewell-Smith.)

pericemental irritation. For these reasons it is wel
to permanently fill the canal immediately after pul
moval. Cotton dipped in a saturated solution of th
in alcohol may be inserted in the canal and allow
remain for one or two weeks, after which the canal
be permanently filled.

DEGENERATIVE DISEASES OF THE PULP

Definition.—The degenerative diseases of the pulp are those changes occurring in the organ due to an alteration of its nutrition as a result of injury, chemical or carious irritation, or senility. They may be classified under the following heads: (1) Fibroid degeneration; (2) atrophic degeneration; (3) fatty degeneration; (4) calcareous degeneration, the latter occurring most frequently.

Fibroid Degeneration of the Pulp

Definition.—The change of the normal tissue elements of the pulp into a *fibrous formation,* which occurs as a distinctive form of degeneration with age.

Etiology.—Hopewell-Smith,[1] who first directed attention to this condition, believes it to be due to senile constitutional changes. This investigator says: "Further investigations will go to prove that it is a natural old-age termination of the life of a healthy pulp." Beyond this no etiological association has been made of the disease.

Pathology and Morbid Anatomy.—"No trace of cellular organization, no vestige of cell nuclei, no remains of interstitial cement substance can be found anywhere.

"Nerves, cells, blood vessels, odontoblasts, have alike shared the process of fibrication, and are no longer recognizable, and the connective tissue, which is but a loose mass of network in the normal state, has either become grossly hypertrophied or quite obliterated, and its place taken by a new, firm fibrous structure, devoid of cells, nuclei, or any regular arrangement of constituent parts."

Fig. 70 represents a section of pulp fibroid degeneration

[1] Hopewell-Smith, "Patho-histology."

conspicuously marked by areolar spaces. These are transverse sections of the blood vessels of the pulp, which they might easily be mistaken. "They are, the

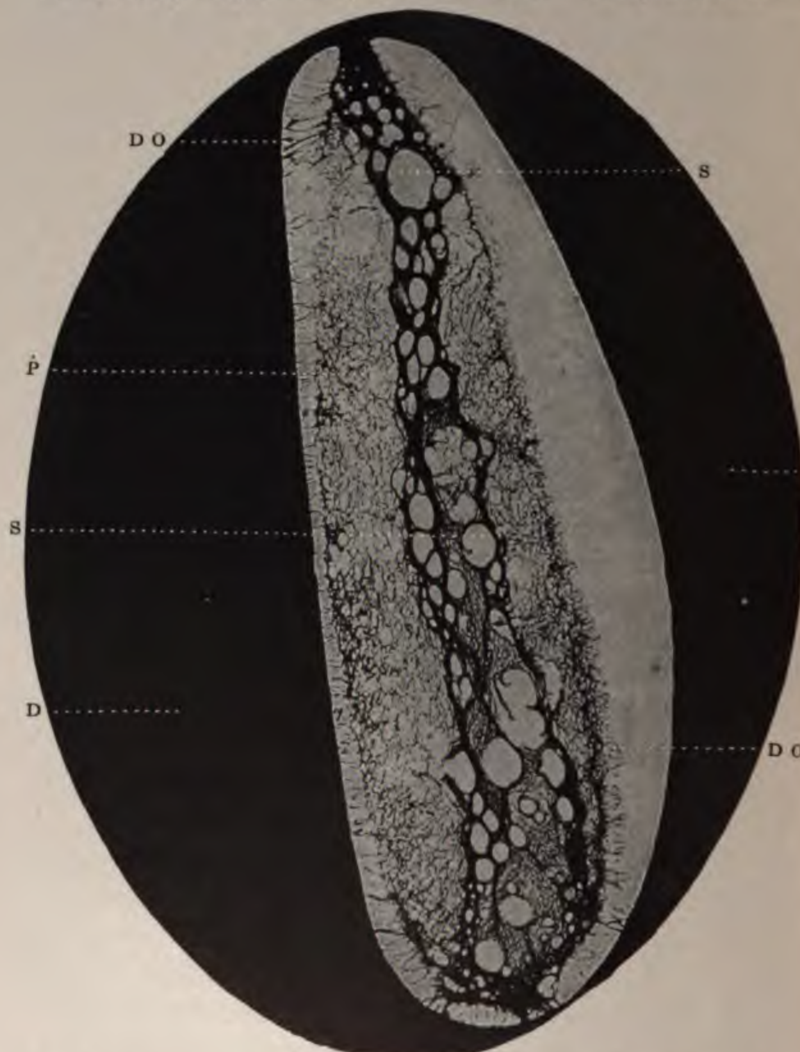

FIG. 70.—HORIZONTAL SECTION OF FIBROID DEGENERATION OF THE PULP *in Situ.*

Prepared and stained as in Fig. 389. Same magnification. D. Deeply stained dentin; S. Large areolar spaces; D.O. Degenerate odontoblasts; P. Fibroid tissue of the pulp. (Hopewell-Smith.)

fore, simply long cylinders with thin but tenacious boundaries.

"'It is probably extreme cases only that exhibit so remarkably the chain of areolæ. Earlier stages seem to indicate that the fibrosis originally began in the central portions of the pulp, in the vicinity of the arterial and nervous systems, and that the region of the basal layer of Weil and the odontoblasts were the last to undergo the metamorphosis, as the cells at the periphery of the pulp are the last to retain their shape and nuclei."

Diagnosis.—As pulp fibrosis appears to be due to senile changes, evidence of this state, such as loosening of the teeth due to alveolar resorption (not pyorrheal), and other symptoms of senility, may presuppose the fibroid state of the pulp, but the microscope alone can definitely determine the condition of the pulp.

Therapeutics.—As the disease can only be diagnosed by microscopical examinations, and as it marks the termination of the vital processes of the pulp, no treatment can logically be applied excepting that of pulp removal and root filling.

Atrophic Degeneration of the Pulp

Definition.—A shrunken and condensed state of the pulp due to an interference with its nutrition, arising from senility.

Etiology.—No cause beyond that of *senility* has been ascertained. It appears to be an antecedent state to fibroid degeneration, and indicates the termination of the vital cycle of the pulp.

Pathology and Morbid Anatomy.—"The odontoblasts in early stages are shrunken; if the atrophy has far advanced they will have disappeared." Walkhoff, in

describing the condition, says: "The pulp tissue has become condensed and permeated with cells, the vessels are considerably dilated, and presumably indicate the extent of the alterations which the organ has experienced. Sometimes the odontoblasts fuse into sheaves or layers, so that they can no longer be individualized. The pulp tissue proper exhibits numerous globular spaces, and there is accompanying reticular atrophy."

Fatty Degeneration of the Pulp

Definition.—The appearance of fatty changes in the walls of the blood vessels and nerves. The odontoblasts show similar changes. According to Hopewell-Smith, "the disease is found in senile teeth, temporary teeth which are undergoing absorption, and in teeth the pulps of which have been capped."

Calcareous Degenerations of the Pulp

Definition.—Under this heading will be included not only those types of calcareous degenerations which occur as the result of an infiltration of inorganic material into degenerative areas of pulp tissue, but also the so-called *adventitious dentins* and *tubular calcification.* These calcific formations, whether of one or another variety, are to be found as the result of an altered vital state of the pulp; therefore, they are pathologic and in no sense physiologic. The subject will be discussed under the following divisions:

(1) Adventitious (secondary) dentins.

(2) Tubular dentinification.

(3) Pulp nodules.

(4) Deposits of calcium salts in degenerated parts of the pulp.

Adventitious Dentins.

Definition.—A formation of dentin occurring as a secondary effort of the pulp in its attempt to protect itself from the encroachment of pathologic factors. It is always added to the primary dentin and may quite readily be distinguished from the first formation by its color. Histologically five varieties have been noted:[1] Areolar, cellular, fibrillar, hyalin, and laminar.

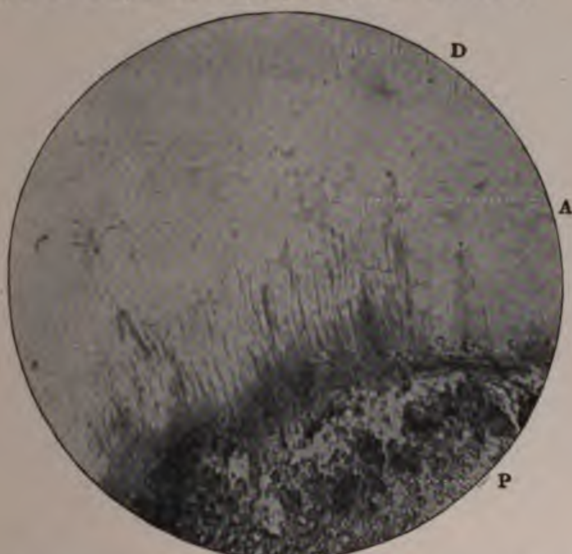

FIG. 71.—AREOLAR ADVENTITIOUS DENTIN. MAGNIFIED 250 TIMES. D, Primary dentin. A. Areolar dentin. P, Pulp tissue. (Hopewell-Smith.)

Etiology.—Adventitious dentins are formed as the result of stimulation of the peripheral cells—*not odontoblasts*—of the pulp. Caries, thermal shock through metallic fillings, irritation of the tubular fibrillæ through loss of the enamel covering, as occurs in abrasion and erosion, in fact, any condition competent to stimulate the pulp to formative activity, may result in a deposition of

[1] Hopewell-Smith, "Patho-histology."

secondary dentin. Exposed pulps with and without fra-ture of the crown have been found to be covered wi dentinal formations. (See Fig. 69, illustration of inju of the pulp resulting from fracture.)

Pathology and Morbid Anatomy.—The existence any of the conditions noted under the etiology of ac ventitious dentins results in a revival of the function activity of the peripheral cells (not odontoblasts) of th

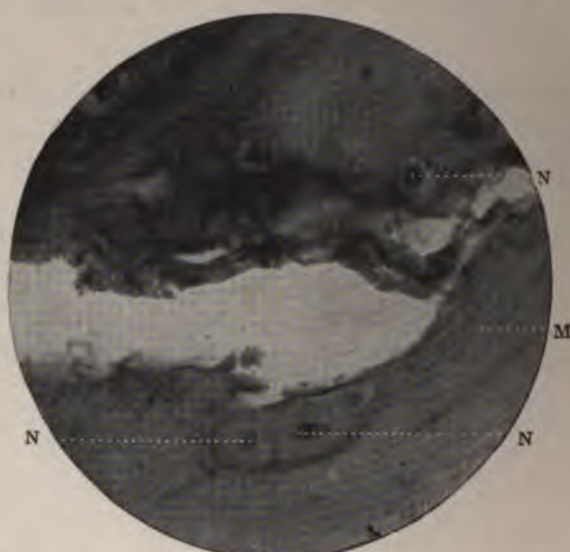

FIG. 72.—CELLULAR ADVENTITIOUS DENTIN. MAGNIFIED 250 TIMES. N, Nuclei of encapsuled cells; M, Matrix. (Hopewell-Smith.)

pulp, and one of the five kinds of secondary dentin formations is thrown out as a tissue of repair, according to Hopewell-Smith the most frequent formation being the *areolar,* which resembles dentin filled with inter-globular spaces. It may be associated with the fibrillar variety, as shown in Fig. 71. The *areolar variety* may or may not contain tubes; or the secondary formation may assume the characters of the above kind and be

further marked by the presence of cells in the matrix. This is the so-called *cellular*, illustrated in Fig. 72, the connective tissue cells of the pulp becoming encapsulated in the calcifying matrix.

The *fibrillar variety* bears closest resemblance to normal dentin. The tubes are finer and branch off in a

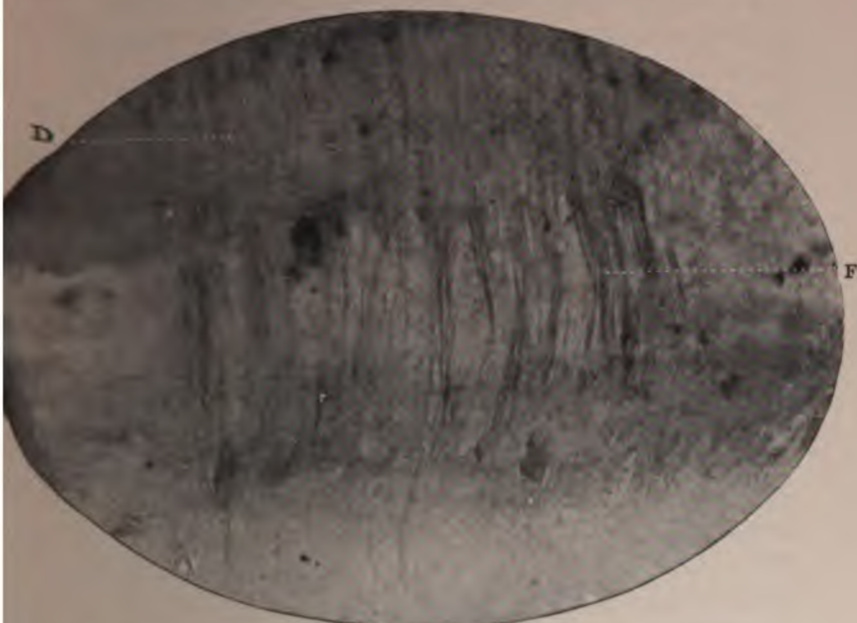

FIG. 73.—FIBRILLAR ADVENTITIOUS DENTIN. MAGNIFIED 250 TIMES.
D, Primary dentin; F, Fibrillar dentin. (Hopewell-Smith.)

different direction from those of the normal dentin. Hopewell-Smith[1] regards the linear markings of this type of secondary formation as being, most probably, connective tissue fibers and not tubes. This is in consonance with his view that the odontoblasts are not engaged in these constructive efforts. Fig. 73 shows the tube-like feature of the formation.

[1] "Patho-histology of the Teeth."

The *hyalin* adventitious dentin is so named from its resemblance to hyalin cartilage. Its location is usually "the base of the carious excavation into the pulp cavity"; the smooth, glass-like appearance of the formation may vary, and we may find a granular or fibrous appearance. According to Hopewell-Smith,[1] it is associated with chronic inflammation of the pulp, especially the productive kind, resulting in the so-called "pulp polypus."

In the *laminar* variety laminated spherites are found similar to those of pulp nodules. Hopewell-Smith says: "It is possible that these bodies are metamorphosed pulp nodules."

Diagnosis.—In excavating a carious cavity the secondary formation may be uncovered and detected by its darkened appearance, or, in the act of pulp removal, the partial occlusion of the canals indicates more or less of a secondary formation. Furthermore, as these formations usually lead to pulp degeneration, the reflex disorders arising therefrom may be the means of suspecting the condition of the pulp in the absence of any other tangible cause and may be said to be due to excessive dentinal formations.

Therapeutics.—No form of treatment for the condition *per se* can be applied. In those cases in which the pulp gives evidence of retrogressive changes owing to these formations it should be removed. Frequently this is attended with considerable difficulty, owing to the constriction, and, in some cases, occlusion for a certain depth of the canal.

[1] "Patho-histology of the Teeth."

Tubular Dentinification

Definition.—Constructive changes in the walls of the tubes of the dentin tending to their obliteration.

Etiology.—The apparent cause appears to be an irritation of the tubular fibrillæ not exceeding the constructive stage, inducing calcific deposits against the tubular walls, gradually lessening the diameter of the opening as well as that of the fibrillæ. The pathological condition is frequently classed under abrasion and erosion, and is also regarded as a normal vital change occurring with age (senile dentin).[1] It also occurs under carious irritation in the form of the *transparent zone,* which may be regarded as a modified form of the disease. Individuals with sclerotic tendency may show this local expression of it, which is the view of Walkhoff,[2] the intercellular substance, or tubular walls, being formed at the expense of the cellulæ or fibrillæ.

Pathology and Morbid Anatomy.—No definite knowledge exists as to the exact manner in which these changes occur. The cause or causes acting either from within or locally lead to a deposition of calcific material within the tubule walls, wholly or partially, occluding them throughout their extent. The atrophy of the fibrillæ usually renders the dentin hyposensitive, although in the early stage of the disease a hypersensitivity of the tissue may exist.

Therapeutics.—As the disease can only be regarded in most cases as an attempt to arrest the progress of caries, abrasion, or erosion, no treatment is indicated.

[1] Burchard's "Pathology."
[2] *Ibid.*

Pulp Nodules

Definition.—Calcific formations generally occurring within the body of the pulp, presenting a fairly definite structure, rarely containing any dentinal tubes, apparently the result of the conversion of the small, round cells of the pulp.[1] The long fusiform cells of the pulp may also be converted into nodules, in which case the node may disclose a few fine dentinal tubes radiating from the center outward.[2] When the nodule is attached to the wall of the pulp cavity, it is due to the formation of secondary dentin, which finally encircles the nodule.

Etiology.—These formations usually exist in teeth the pulps of which have been irritated by abrasion, erosion, or caries, although they are also found in apparently healthy teeth, in which cases their exact origin is unknown. They are also found in patients with a gouty diathesis. Dr. Black notes[3] that pulp nodules may be formed in teeth the pulps of which are not directly but indirectly irritated; that is, irritation of the pulp of one tooth may reflexly induce a pulp hyperemia in another tooth.

Pathology and Morbid Anatomy.—Pulp nodules when fully formed usually show upon section a concentric laminar formation; they may be structureless, or, as previously noted, may contain a few fine tubes running outwardly from the center, formed by the conversion of the long fusiform cells of the pulp. Owing to the altered vital state of the pulp, due to irritation, its cells secrete calcoglobulin, which may be converted into spherites. Under the continuance of the irritation addi-

[1] Hopewell Smith, "Patho-histology."
[2] *Ibid.*
[3] Burchard's "Pathology and Therapeutics."

tional material is deposited, until the mass produces pressure upon the nerve filaments of the pulp, followed by pain. Hopewell-Smith says:

"Having studied these depositions of lime salts under many conditions, and possessing sections which exhibit various stages in their development and growth, the writer has come to the conclusion that they are formed by a secretion or conversion of the small, round

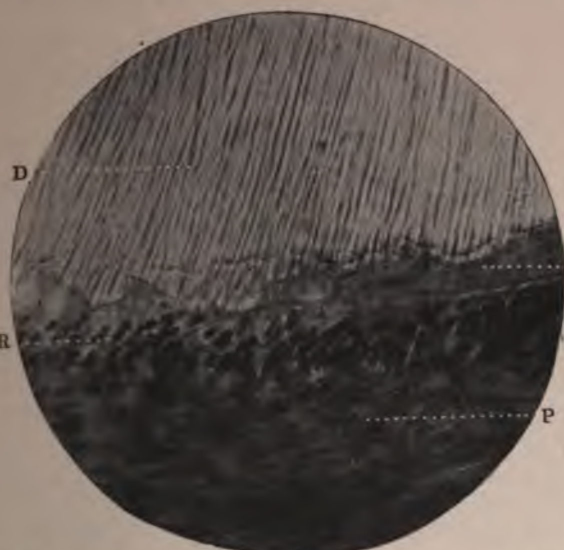

FIG. 74.—THE METHOD OF CONSTRUCTION OF THE DENTIN OF A PULP NODULE.

Prepared by Weil's process. Magnified 250 times. D, Formed and calcified dentin; DZ, Dentogenetic zone; R, Round cells forming the dentogenetic zone; P, Pulp tissue. (Hopewell-Smith.)

cells of the pulp (Fig. 74). This process may end in the total obliteration of cell wall and nucleus, or the cell itself may persist *in situ*."

Fig. 75 shows the structure and formation of a pulp nodule. A pulp nodule may contain a pulp chamber in its interior. The following is Hopewell-Smith's account of such a case:

"Three teeth were removed from the same mouth, on account of excruciating and incurable pain. The pulps contained the largest nodules probably on record. One of them measured in width 2.5 mm. and in length 10 mm. Extending in the central axis of the nodule is a canal filled with ordinary pulp tissue. In one section the outermost part of the nodule consisted of fine-tubed orthodentin, which gave the growth a conical shape. Inside

FIG. 75.—CENTRAL NUCLEAR FORMATION OF A PULP NODULE AND CONCENTRIC LAMINATION. (Hopewell-Smith.)

this and filling up what at one time must have been the pulp cavity was a mass of calcareous material, with still a small amount of pulp tissue remaining. The central hard mass contained a granular matrix, in which were embedded great numbers of lacunal and interglobular-like spaces. Here and there a few scattered dentinal tubes radiating centripetally were arranged in bundles. Such cases have never been described before; but they are probably not unique."

Symptoms.—No symptoms pathognomonic of the disease exist. Pulps have been removed from teeth which, upon examination, were found to contain pulp nodules, in relation to which no pain existed at any time. On the other hand, patients have experienced most excruciating pain referred to different localizations upon the head and face, and which, after removal and examination of the pulp, were apparently due to the presence of pulp nodules. Dr. Guilford reported a case of tic douloureux of two years' standing, the result of pulp nodules (Burchard). The dentin of the tooth usually shows an excessive hypersensitivity, and narrow thermal deviations are sufficient to set up severe neuralgic pains. If the pulp of a lower tooth is the seat of the deposit the patient usually complains of a pain *in the ear.* If arsenic be applied for devitalization it will be found, after two or three days, to have had little or no effect beyond that of pulp irritation. Repeated applications may fail of the purpose of pulp devitalization; so, too, with cocain and pressure. In fact, quite frequently it will be found that those pulps that have been the seat of long-standing irritation, owing to the presence of pulp nodules, can be removed only under a general anesthetic.

Diagnosis.—The presence of pulp nodules may be inferred from the history, which discloses a long-standing neurálgia affecting different parts of the face and head, together with an exquisite hypersensitiveness of the dentin, the failure of anodynes to reduce the pain, and the tardy and at times ineffectual action of arsenic. When these conditions exist the diagnosis may be made positive by utilization of the X-ray. Fig. 76 illustrates the positive value of this mode of making the diagnosis.

Therapeutics.—With a positive diagnosis of the con-

dition, the rational treatment is pulp removal. This may be attempted, first, under cocain and pressure; if ineffectual, arsenic may be applied. As previously indicated, its action is likely to be tardy, and in some cases its only effect will be one of severe irritation manifested in an excruciating pain. If, after the first application, a nearer approach to the pulp may be comfortably made, a second application will usually allow of the exposure of the organ, after which another application allowed to act for a week will be found to completely devitalize the pulp. However, if the first or second applications are entirely negative in their effect, the pulp should be removed under a general anesthetic. Dr. Burchard[1] calls attention to a pericemental irritation frequently arising after the removal of these pulps, and advises the thorough death of the pulp filaments before attempting their removal.

FIG. 76.—PULP NODULES IN THE RADICULAR AND CORONAL PORTIONS OF THE CANAL. (Skiagraphs by Price.)

Amorphous Calcific Degeneration of the Pulp

Definition.—This condition implies an infiltration of inorganic material, not attaining any special form, into dead or degenerated areas of the pulp.

Etiology.—If from any cause the nutritive balance of the pulp is destroyed, its cells finally degenerate and die. A reaction very likely occurs between the albuminous base of the cells and the inorganics contained in the lymph, gradually infiltrating the tissue. These reactions are favored by a sluggish circulation.

[1] Burchard's "Pathology and Therapeutics."

Pathology and Morbid Anatomy.—With the loss of the nutritive balance of the pulp its cells degenerate and die. Between the albuminous base of these cells and the inorganics of the stagnant blood present a reaction occurs, similar to that seen in other parts of the body, resulting in a calcification of both cells and intercellular substance. Other portions of the pulp are still vital, but show degenerative changes in the loss of its cellular elements. These may be superseded by fibrous formations, and the calcifications may assume the form of the fibers (Fig. 77). It is claimed[1] that these pulps

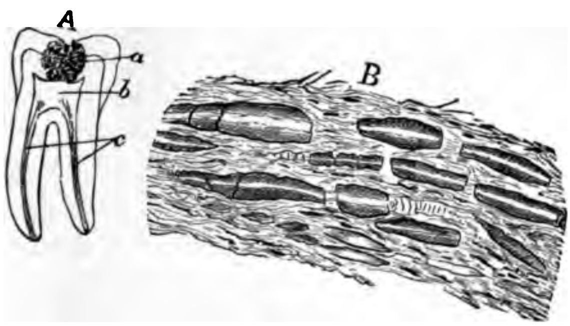

Fig. 77.—*A*, outline of a lower molar, with a large carious cavity at *a*; *b*, pulp chamber; the shaded portion, *c*, was occupied by cylindrical calcifications. *B*, cylindrical calcifications. x 100. (Black.)

upon removal "have a granular feel to the fingers, and when dry are quite stiff."

Symptoms.—The symptoms are those of chronic pulp degeneration. Reflex pains, as a rule not severe, delayed response to hot and cold applications, the hot usually eliciting a greater response. These symptoms are dependent upon the degree of degeneration that has taken place. In some instances the thermal test will reveal little, if any, response, showing an almost complete state of pulpal degeneration.

[1] Burchard's "Pathology and Therapeutics."

Diagnosis.—The reflex pains and the delayed response to severe thermal changes indicate the degeneration of the pulp, but the presence of the calcific infiltrations can only be inferred, unless the X-ray or post-mortem examination should reveal them. Fig. 78 illustrates a case occurring in the practice of Dr. Burchard, the state of the pulp being discovered upon fracture of the tooth in its extraction.

Fig. 78.

Therapeutics.—The remaining vitality of the pulp should be destroyed by an arsenical application, or the pulp may be benumbed by means of cocain and pressure and removed. The low degree of vitality present in the organ makes either mode of treatment a speedy means of pulp removal.

CHAPTER XV

DISEASES OF THE PERICEMENTUM

The pericementum, like the dental pulp, is the seat of a variety of diseases which may temporarily or permanently impair its function, and lead to alterations in its structure. The similarity may also be extended to the bony casement of the dento-alveolar ligament. This does not quite as completely interfere with the outpouring of the exudation in inflammatory conditions as may be noted in like conditions of the pulp, in which the bony surroundings almost completely restrict the exudation and thus thwart all efforts at healing. In pericementitis the exudate is forced between the tissue elements of the membrane, lifting the tooth from its socket. This provides the most valuable diagnostic symptoms when the membrane becomes the seat of vascular disturbances, viz., looseness of the tooth and pain when pressure is made upon it.

In considering the cause of the reflex pains associated with pulp diseases, it was found to be due to the absence of tactile corpuscles from the pulp. As these are found in the pericementum, the sense of localization is thereby provided for this membrane. Pressure exerted upon a tooth the pericementum of which is affected results in a definitely located pain; this further distinguishes between diseases of the pulp and those of the pericementum. Furthermore, as the blood supply of the pericementum is related with that of the gum through

inosculation of the blood vessels at the gum border, disturbances of the pericemental blood supply are usually followed by an engorgement of the vessels of the gum overlying the affected tooth indicated by a deepened red color. This provides another sign almost always available for the symptomatology of pericemental diseases.

The symptoms of pericemental affections, therefore, are clearly differentiated from those of the pulp, in which were chiefly noted reflex pains and response to thermal stimuli. In diseases of the pericementum we find, as a rule, definitely located pains upon percussion, extrusion and looseness of the tooth, and discoloration of the overlying gum tissue.

Classification.—The difficulty attending an attempted grouping of the various pericemental diseases is as great as that found to exist in relation to pulpal diseases. As our pathological knowledge of the diseases of both organs is limited, an exact classification is impossible. Dr. Black [1] made the following: (1) Diseases of the pericementum beginning at the apex of the root; (2) those beginning at the gum margin; (3) those beginning in some intermediate portion of the pericementum. This has been quite generally accepted, and affords a convenient clinical consideration of these disorders.

DISEASES OF THE PERICEMENTUM BEGINNING AT THE APEX

These are subdivided into two classes, (1) septic, (2) non-septic.

Class 1—Septic Diseases

Acute Septic Apical Pericementitis

Definition.—The phenomena of inflammation occurring in the apical region of the pericementum generally

[1] Burchard's "Pathology."

following the entrance of *pathogenic germs* or *toxic ptomains* from a putrescent pulp canal.

Etiology.—As above indicated, the causes of *acute septic apical pericementitis* are, generally, *pathogenic bacteria* and *toxic ptomains* escaping from a putrescent pulp canal. Cases of apical pericementitis are recorded in which the infecting organisms gained entrance to the apical tissue through some other avenue than the root canal. That this may occur we have but to consider those cases of moist gangrene of the pulp which are occasionally present in teeth entirely free from caries. In these cases the infecting organisms found in the canal must have entered either through the apical opening from the general circulation or possibly by passing through the cementum and dentin at the neck of the tooth. The apical tissues may also become infected by the extension of an abscess located upon the root of an adjoining tooth, or a pyorrhea pocket may be the means of conducting pyogenic organisms into the apical area. In a paper entitled "On the Etiology and Pathogenesis of Dental Periostitis," by Dr. Emil Schreier, printed in the *Cosmos,* 1903, he reports his conclusions from a series of investigations undertaken to determine the nature of the infecting organisms. He says: "In all of the cases examined by me three species were found, viz., staphylococcus, pyogenes, both aureus and albus, and diplococcus pneumoniæ. I wish to lay special stress on the circumstance that no species ever appeared in the cultures, which might have been regarded rather arbitrarily as an accidental contamination, to be left out of account. The almost constant occurrence of the diplococcus pneumoniæ is remarkable." Further on he again says: "The most usual exciter of these affections is the diplococcus pneumoniæ." These conclusions with

reference to the last-named organism have not been verified, but that the disease under consideration, in the majority of cases, is etiologically identified with pyogenic organisms cannot be doubted, and is strongly supported by pathological as well as other knowledge.

Pathology and Morbid Anatomy.—With the entrance of pyogenic organisms or toxic ptomains into the apical tissue a vascular reaction occurs, expressed at first as an arterial hyperemia; *the patient becomes conscious of the tooth,* and experiences an increasing tenderness in pressing upon it. This may continue for 24 or 48 hours, when the venous flow becomes stagnant, followed by the distinctive pathological phenomena of inflammation, viz., diapedesis of the white blood cells and the outpouring of the fibrinous exudate. The pericemental tissue becomes infiltrated and its fibers swollen. The cells increase in number. "The osteoblasts are particularly visible, and depositions of new cementum with irregular lacunæ and canaliculi often occur."[1] The accompanying figure illustrates the fibers of the pericementum crowded with leukocytes and inflammatory products (Fig. 79).

With the swelling of the fibers and the collection of fluid and cells at the apex, the tooth extends from its socket and is loosened. The gum color changes from a light pinkish hue to a deep red color. A continuance of the morbid processes results in a peptonizing and liquefying of the apical tissue. In other words, pus is formed and an apical abscess has been established. This has been designated the first stage of pus formation.[2]

The second stage signifies an involvement of the surrounding bony structure and usually marks the most

[1] Hopewell Smith, "Pathohistology."
[2] Burchard's "Pathology."

painful period of the disease. With this stage the cheek or lip, if an anterior tooth is affected, or both, are markedly edematous, and the bone cells are in process of destruction. This continues until the alveolar plate is finally perforated, which usually occurs labially, as the labial plate is the thinnest.

The perforation of the alveolar plate and destruction of its periosteum mark the beginning of the third stage

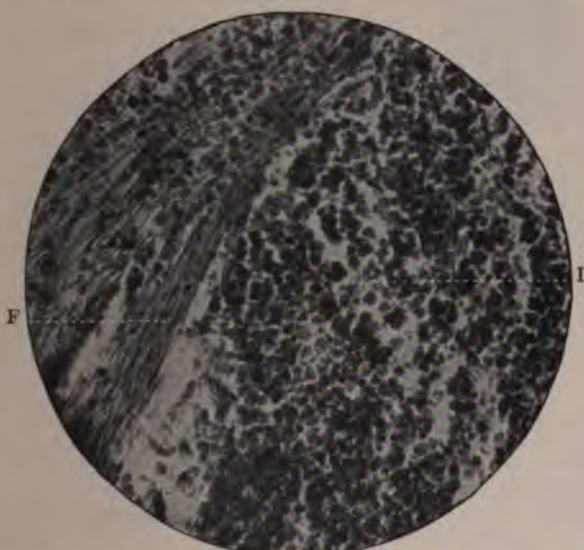

FIG. 79.—F, CONNECTIVE TISSUE FIBERS. I, INFLAMMATORY CELLS AND PRODUCTS. (Hopewell-Smith.)

of pus formation. Pus is now directly beneath the gum tissue, which is pushed forward as pus formation continues beneath. The peptonizing and liquefying of the gum tissue proceed until it is finally perforated, forming a fistulous opening for the discharge of the pus. Fig. 80 illustrates the morbid process. Under our present knowledge of the etiology of acute apical septic pericementitis three species of organisms have been

named: the staphylococcus pyogenes albus and aureus, and the diplococcus pneumoniæ. Occasionally a diffuse inflammatory reaction may be seen spreading down the neck and involving the connective tissues and lymphatics. With these symptoms those of septicemia may also be noted. These cases very likely are due to a streptococci infection, and should receive prompt and efficient therapeutic aid in order to avoid serious complications.

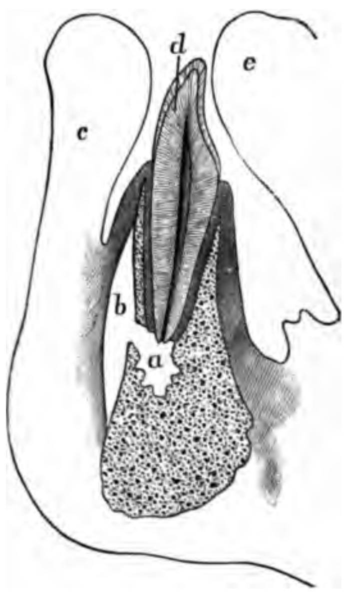

FIG. 80.

With the discharge of the pus, which usually occurs at the buccal or labial aspect at a point near the end of the root, as previously noted, and the thorough elimination of all infective material, regeneration of tissue takes place and the tooth returns to a state of comparative normality. In some cases, however, of inferior molars, or in abscess located upon the lingual root of a superior molar, the increased thickness of bone may offer unusual resistance to the destructive advance of pus, in which cases the pus travels along the side of the root and finally discharges at the gum margin. These cases end in loss of the tooth through destruction of the alveolar plate, unless prompt aid is rendered for the thorough destruction of all infective substances, prohibiting further pus formation, or inducing its discharge over the end of the root by surgically establishing a fistula. So, too, may we find central incisors with long roots, lying

in close proximity to the floor of the nose. When the apical ends of these roots become the seat of pus formation the floor of the nose may be easily perforated and the discharge of pus may take place in the nasal cavity. The roots of the superior first and second molars may be separated from the *antrum* by a very thin bony layer, easily perforated by pus located at the root end (Figs. 81 and 82).

Symptoms.—The symptoms of acute septic apical pericementitis, as a rule, are clearly defined and easily

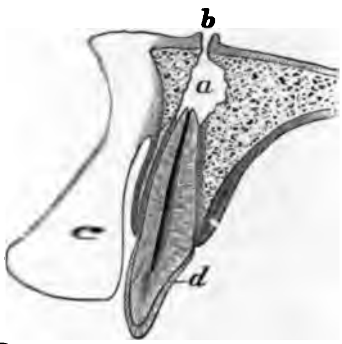

FIG. 81.—MOLAR ABSCESS AT THE ROOT OF A SUPERIOR INCISOR, DISCHARGING INTO THE NOSE: *a*, cavity in the bone; b, mouth of fistula on the floor of nostril; c, lip; *d*, tooth.

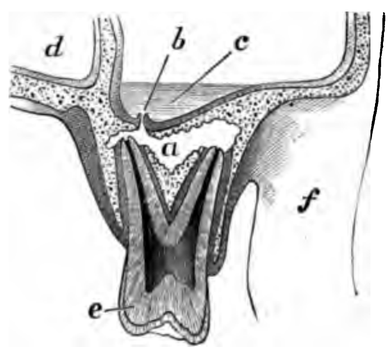

FIG. 82.—ALVEOLAR ABSCESS AT THE ROOT OF AN UPPER MOLAR DISCHARGING INTO THE ANTRUM OF HIGHMORE: *a*, abscess cavity in the bone; *b*, mouth of fistula on the floor of the antrum; *c*, pus in the antral cavity. (Black.)

recognized. The crown has lost its translucency, it is opaque, more or less loosened and extruded, and pain is elicited when pressure is made upon it. The overlying gum tissue is darker than that of the neighboring part. The patient reveals a history, first of the enforced consciousness of the presence of the tooth, followed by tenderness during the act of biting. This represents the *arterial hyperemia* in the apical region following the irritation of the infective agents from the canal. This usually continues for 24 or 48 hours, and

is followed by venous congestion, with its sense of fullness and heaviness, also that of increasing elongation of the tooth, with its increased tenderness when force is exerted upon the tooth. It is at this stage of apical disturbance that the patient usually takes cognizance that heat in contact with the affected tooth increases the pain, most probably due to the increased pressure upon the apical tissue from the expansion of the gases within the canal.

Following the stage of venous hyperemia is that of inflammation, with the emigration of the leukocytes and the outpouring of the fibrinous exudate into the perivascular tissue. The pain now is intense and throbbing. The patient is unable to bring the teeth in contact without acute suffering; the tooth is freely movable in its socket, and the overlying gum is considerably deepened in color. The tooth reacts severely to heat. If the throbbing pain has persisted for 24 hours we can be reasonably assured that pus is present in the apical region. In many cases these symptoms are supplemented by those of septic intoxication, due to the absorption of bacterial products; and the degree to which this may develop depends upon the nature of the toxic products, the amount absorbed, and the resistive qualities of the patient. In some cases, usually those where the patient delays seeking therapeutic aid, the systemic effect may reach a septicemia, indicated by a high temperature, feeble pulse, nausea, vomiting, headache, and evidences of general prostration.

Diagnosis.—The clearly defined symptoms, as a rule, leave no doubt as to the nature of the affection. While it is true that in other varieties of pericemental diseases the symptoms resemble those of acute septic apical pericementitis, in none do they all reach the acute form

presented in this grade. If, however, any doubt should exist as to the diagnosis, entrance into the pulp canals quickly dispels it. The presence of pus at the apical end may be safely suspected if a throbbing pain has persisted for 24 hours. In the disorder designated pericemental abscess, which may be mistaken for an acute apical abscess, the confirming evidence of moist gangrene in the canal does not exist. Pericemental abscess usually occurs upon the root of a tooth the pulp of which is vital, or, if devitalized, is not involved in a putrefactive process.

Prognosis.—This is directly dependent upon the promptness and thoroughness of the applied therapeusis. If all infective and irritating substances are removed the tooth returns to a state of comparative normality and is retained.

Therapeutics.—The first step in the treatment of this disease lies in effecting an entrance into the pulp canal, or canals, if a multirooted tooth is affected. This is of the greatest importance at almost all stages of the disease, excepting, perhaps, in the *third stage* of pus formation, in which penetration of the gum tissue will result in an outlet for the accumulated pus and bring with it almost immediate relief. In these cases it would be manifestly unwise to make an opening through the tooth into the canal, when the pus is so near the exterior that the gum tissue alone prevents it from discharging into the oral cavity.

The opening into the canal is usually made under considerable inconvenience to the operator and pain to the patient. The crown of the tooth should be securely held between the thumb and index finger of the left hand, to counteract the pressure necessary to make the opening; or a ligature may be tied around the tooth, as

suggested by Dr. Flagg, and counterpressure made by the patient. The best results usually are obtained with the former method. The opening leading into the canal or canals being made, the cavity is sprayed with an antiseptic solution and dried. A fine probe is passed into each canal to free it of any obstruction; precaution here must be carefully exercised not to force any portion of the canal contents through the apical opening, otherwise all abortive efforts will be defeated; the formocresol mixture on cotton is placed over each opening and the cavity closed with zinc phosphate.

The gum over the affected tooth should be painted with a pledget of cotton containing one drop of the Tr. of aconite,[1] the lip or cheek being held away to prevent the saliva washing away the application. This is followed by an application of Tr. of iodin, preferably applied in spots. The anodyne and counterirritating effects of these drugs prove materially helpful in restoring a comfortable state. As an additional therapeutic aid a gutta percha cap may be adjusted over an adjoining tooth, so as to secure surgical rest to the affected tooth; or, if this is impracticable, zinc phosphate may be applied to the occlusal surface of the approximating tooth, so that when the teeth come in occlusal contact stress is withheld from the affected pericementum. Derivative measures, such as the administration of saline cathartics, of which citrate of magnesium, as a rule, is most palatable, or immersing the feet in hot water until well reddened, together with the internal administration of a diaphoretic, for which 10 grains of Dover's powder answers admirably, are all useful aids in reducing the vascular

[1] The dental Tr. of aconite or iodin, which is about four times the strength of the official preparations, may be used.

engorgement of the pericementum. This is the plan of the abortive treatment.

If, however, the presence of pus is suspected in the apical region, of which we may be reasonably assured if the patient affirms the existence of a *throbbing* pain for 24 hours, the former plan of treatment may be abandoned, as it serves but to delay the return to a comfortable state, excepting, perhaps, in those rare instances where drainage through the canal is sufficient. This may occur in single-rooted teeth with rounded canals, such as we find in the superior anterior teeth, and where gravity favors the downward flow of the pus, but rarely, if ever, in other locations. In these the surgical procedure is at once indicated. The gum is desensitized with an application of Tr. of aconite, or phenol, or a 1 per cent. solution of cocain, and an incision is made to the bone; cotton dipped in alcohol is forced into the incision; this distends the opening to afford greater convenience for the perforation of the alveolar plate, and also clears the field of blood and septic organisms that may have gained entrance to the part during the minute or two of rest. A second application of cocain is made into the gum opening, after which the alveolar plate overlying the end of the root is perforated by means of a trephine or drill carried in the engine. The simplicity of the technique of the surgical procedure strongly recommends it, and, although it may be argued that, inasmuch as the exact location of the underlying pus is not known, therefore the perforation of the alveolar plate accomplishes little good, nevertheless, while drainage may not immediately follow the operation, it certainly is not thereby delayed, and in all probability will be hastened by reason of the existing opening.

In place of the surgical procedure many operators

prefer the abortive treatment, as previously described, and, if that fails to establish a cure, the opening leading into the canal is closed, a capsicum plaster is placed over the gum, and by the use of narcotics or hypnotics a tolerant state is hopefully established until the pus has reached the gum tissue. This usually requires from 24 to 48 hours. While the procedure may be regarded as not being in accord with surgical and pathologic knowledge, at times no alternative exists but loss of the tooth. Where several days elapse before the pus discharges through the gum opening, evidences of septic intoxication generally will be found. This condition is successfully combated by the use of antipyretics. The following is a useful combination:

℞	Saloli	aa grs. xv
	Acetanilidi	
	Quininæ sulphatis	grs. xjj

M. Et ft. Capsulæ No. vj.
Sig.—One every two hours.

If quinin is contraindicated, the following may be given:

℞	Saloli	aa grs. xv
	Acetanilidi	
	Phenacetin	
	Strychninæ sulph.	gr. 1/10

M. Et ft. Capsulæ No. vj.
Sig.—One every two hours.

With the discharge of the pus, the symptoms, both local and general, quickly subside. The canal treatment is now similar to that of moist gangrene, and, if effectively carried out, a return of the tooth to a comparatively normal state may be confidently expected. The many instances of unsightly scars following the use of

hot external applications call forth an emphatic warning against such practice. No excuse can be found for an act that invites the external discharge of pus, and such recommendation to the patient can only arise from complete ignorance of its therapeutic effect.

In many cases of acute apical abscess, after the discharge of the pus from the gum fistula and the treatment of the canal, the acute symptoms subside, the tooth shows little, if any, tenderness when pressed upon, and apparently returns to its former useful state; but pyogenic infection continues, as may be verified by pressing upon the gum in the region of the existing fistula, when a purulent discharge will appear from the opening. This condition may exist for a period of years without disturbing the patient in the slightest degree and without disclosing serious complications; in other words, the tooth is the seat of a *chronic apical abscess.*

Chronic Apical Abscess (Chronic Purulent Apical Pericementitis)

Definition.—A formation of pus extending beyond the disappearance of the symptoms of acute apical abscess and discharging in small amount at frequent periods either from a fistula or through the canal of the tooth.

Etiology.—Failure to completely destroy the pyogenic organisms associated with the acute abscess or some other pathological condition apparently explains the continuance of pus formation. The liquefying effect of pus may have produced a roughened alveolar area sufficient to harbor pyogenic organisms, which remain in this location beyond the reach of germicidal agents, continue active, the pus discharging through the original fistulous tract almost immediately after its formation. No symptoms appear, excepting where the opening may

close, allowing the pus to accumulate and terminating in a renewed acute pyogenic activity.

Pathology and Morbid Anatomy.—With the determination of the acute process, efforts at healing are quickly inaugurated. The abscess cavity becomes filled with fibroblasts and cicatricial tissue is formed, but the pyogenic organisms remaining in the apical region peptonize and liquefy portions of the repair tissue; new granulations appear, and with efficient remedial efforts directed through the canal no further change may occur. But if the treatment be delayed or prove inadequate the continued irritation of the apical pericementum results in the proliferation of its cells and the formation of a fibrous sack, which in many instances of extraction appears at the end of the root (Fig. 83). As this sack contains septic organisms a glance at the illustration is sufficient to show why germicides fail to destroy the organisms. In other cases the new fibrous tissue is liquefied into pus and no sack is formed. The pus collects about the end of the root, which may become denuded, and burrows along the side of the root until it discharges at the gum margin; or it may work its way into the cancelated portion of the bone, as occurs occasionally in the lower jaw, and finally discharges upon the face or neck (Fig. 84). If a superior tooth is affected the pus may finally appear upon the roof of the mouth (Fig. 85). Hopewell-Smith[1] calls attention to a new growth of the root membrane, consisting of a solid mass of granulation tissue, due to chronic inflammation, and termed *granuloma*.

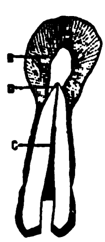

FIG. 83.—CHRONIC APICAL ABSCESS, THIRD GRADE: B, abscess sack, containing a central pus cavity; D, apex of root; C, canal containing pus. (Burchard.)

[1] "Patho-histology."

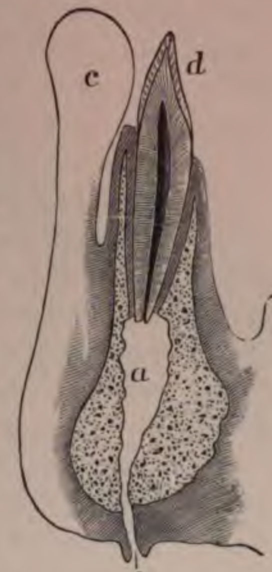

FIG. 84. —CHRONIC ALVEOLAR ABSCESS OF THE ROOT OF THE LOWER INCISOR, WITH ABSCESS CAVITY PASSING THROUGH THE BODY OF THE BONE AND DISCHARGING ON THE SKIN BENEATH THE CHIN:

a, very large abscess cavity; *b*, mouth of the fistula. (Black.)

Symptoms.—The symptoms of chronic apical abscess without fistula are not as well defined as those of acute abscess. A tenderness is generally referred to the affected tooth, which is also slightly loosened and extruded. The gum color overlying the end of the root is deepened and the tooth is discolored. If the bone becomes involved in an inflammatory process, or if interference with the vent to the pus should arise, the pain may become acute. An opening into the canal shows the presence of pus.

Diagnosis.—Chronic apical abscess without fistulous opening may positively be diagnosed by means of the X-ray; or, if a badly discolored crown suggests an opening into the canal for its exploration, and a flow of pus is detected upon the removal of the fine probe, coexistent with which we find the deepened gum color overlying the end of the root, a tenderness upon pressure, and dull pains extending over a period of time, a diagnosis may be made of the disease under consideration.

FIG. 85.—CHRONIC APICAL ABSCESS DISCHARGING THROUGH THE HARD PALATE AND THREATENING TO DISCHARGE LABIALLY. (Burchard).

Prognosis.—This depends upon the thoroughness with which all infective substances contained in the ab-

scess cavity can be destroyed. Where this plan of treatment fails to effect a cure, root amputation or extraction and replantation has resulted in success in a fair percentage of cases.

Therapeutics.—In chronic apical abscess without fistulous opening the dam is adjusted, prior to which the crown should be repeatedly wiped with cotton well saturated with alcohol. With the dam in position the cavity is saturated with alcohol, dried, and a suitable opening is made into the canal. The pus should be allowed to drain freely, and the canal dried by introducing wisps of cotton followed by alcohol. In each canal cotton is introduced well saturated with the formo-cresol remedy and sealed with temporary stopping or zinc phosphate. If the pus has been well drained and no considerable amount appears to be present, the modified formo-cresol mixture may be used, as discussed in the treatment of moist gangrene of the pulp. The value of formaldehyde is in proportion to the amount of hydrogen sulphid, ammonia, and poisonous ptomains in the canal and dental tubuli. The dressing containing the original formo-cresol mixture should be changed every day, until it is observed that the pyogenic process has been checked. This is indicated by the dressing maintaining a degree of integrity upon its removal 24 or 48 hours after its introduction into the canal. The modified formo-cresol mixture may now be introduced, as advised by Dr. Buckley, and the tooth closed for about a week or ten days. This usually suffices for a cure. If, however, upon removal of the last dressing the slightest odor be detected, the remedy may be further modified by adding 2 or 3 drops of cresol to 1 drop of the original formula, and an additional dressing applied in the canal. If the formo-cresol treatment fails to check the pus formation it

is not likely that other remedies will succeed. Very excellent results have been obtained with sodium dioxid, also with the silver nitrate treatment, as suggested by Dr. Bethel. Reference has also been made to the experiments of Mayrhofer with balsam of Peru. But whether these agents have succeeded in establishing a cure of the condition here discussed where failure followed the formo-cresol plan of treatment is unknown to the writers. A word of caution may here be introduced concerning the forcible injection of hydrogen dioxid into the canal of the tooth. The liberation of oxygen when the agent reacts with pus may be followed by great pain, and may retard, if not entirely prevent, recovery of the case. If the treatment as outlined above proves futile, a *fistula* must be made and the case treated as chronic apical abscess with fistula.

Chronic Apical Abscess with Fistula

Definition.—A discharge of pus usually from the gum at a point near the apex of the root, without acute symptoms, and following the discharge of an acute apical abscess. The discharge may occur at some more distant part, as previously noted. (See acute apical abscess.)

Etiology.—Here, as in the chronic abscess without fistula, the active cause unquestionably must be the retention about the apex of pyogenic organisms. In some cases the continued pus formation appears to be due, in part at least, to a lessened tissue resistance; this is made evident by the speedy cure which follows the use of stimulating agents forced through the apex.

Pathology and Morbid Anatomy.—The phenomena noted in chronic apical abscess with fistula do not differ essentially from those in a chronic abscess discharging into the canal, excepting as to the manner of the dis-

charge of pus. The granulation formed as an effort of repair is, in part, destroyed by the pyogenic process, the resultant pus discharging from a small opening in the gum usually located upon the buccal or labial aspect of the gum near the apex of the affected root. Granulation tissue is again formed, only to be prevented from completely healing the diseased area through the activity of the retained septic organisms, the pus discharging as before from the small opening in the gum, the edge of which is thickened and inflamed. Occasionally the fistula is located at a point distant from the affected tooth, determined by the path of least resistance. This should be carefully considered, otherwise an unoffending tooth may be opened and considerable effort ineffectively expended. The pus may burrow along the side of the root, destroying the pericementum, and discharge at the gum margin; or the floor of the antrum may be perforated. followed by fetid discharges into the nasal cavity. These cases give a history of long-standing facial neuralgia, with severe headaches and offensive discharges from the nose. In the inferior teeth the pus may affect the bony structure and finally appear upon the face; or the inferior dental canal may be entered through perforation of the bone and serious complications may ensue.

Symptoms.—An opening is detected upon the gum which usually discharges pus when pressure is made over the affected root. The tissue about the opening is deepened in color. The tooth may disclose a slight tenderness when pressure is made upon it, or no tenderness to pressure may exist. As a rule it is somewhat loosened, also discolored. The thermal test elicits little, if any, response; heat may provoke a slight reaction. If pus fails to appear upon the gum as the result of pressure the patient confirms its existence by stating that

at intervals a swelling appears upon the gum, which upon pressure bursts and discharges a small amount of pus, little, if any, inconvenience being experienced during the act.

Diagnosis.—If the discharge of pus takes place through the gum immediately over the affected tooth, and the neighboring teeth give evidence of pulp vitality, but little difficulty exists in making the diagnosis. If, however, two or more teeth with large fillings and supporting evidence of devitalization are located in the region of the fistula, considerable difficulty may be encountered in determining the offending tooth. An exploring probe should be introduced into the fistulous opening to determine the direction of the abscess tract and probably the affected root. If the origin of the discharge is due to *caries of the bone,* which may simulate apical abscess, the *honeycomb feel* diagnostic of caries will be readily perceived. In necrosis of the bone the overlying tissues are deeply discolored and necrotic, with several discharging fistulæ, and if sequestration has occurred the probe detects the loose bone. With the exclusion of the diseases of the bone, or a retained root fractured during extraction, or possibly an impacted tooth, any of which conditions may be associated with a fistula upon the gum, a careful examination may have to be made as to the state of the canals in each suspected tooth, or an X-ray picture must be made, before a positive diagnosis can be reached.

Prognosis.—This depends upon the effectiveness of the applied therapeusis in removing all infective and irritating substances and inducing thorough repair of the injured and necrosed areas. It is surprising to observe in some instances, in which purulent discharges have extended over a period of years, the ready response and

the restoration of comparative normality upon the application of effective treatment.

Therapeutics.—The essential principle of the treatment is the removal of all infective and irritating substances. Retained roots, impacted teeth, carious or necrosed bone, must be removed. If the condition is due to the retention of infective agents about the apex, or in the canal, measures must be taken to thoroughly eradicate these. The tooth is placed under the dam and the canals opened, flooded with alcohol, and dried. Donaldson's cleansers are then operated in each canal until the apex is passed. This is important, as it enables the operator to introduce remedies into the canal and force them through the opening until they appear at the opening upon the gum. If it appears very difficult to reach the apex mechanically, the operation may be facilitated by the use of 50 per cent. sulphuric acid after the well known *Callahan method.*

Having opened the apex, the next step is to force our remedy through the sinus until it appears upon the gum. For this purpose we require a hypodermic syringe with long straight and curved needles. Special claims have been made for various remedies used to irrigate the sinus. In the writers' estimation more depends upon the thorough irrigation of the long canal, beginning within the tooth and terminating upon the gum, than upon the remedy itself. This is made manifest by the excellent results that have followed the use of the various remedies suggested for the purpose when they have been made to reach all parts of the affected area. Most excellent results have followed the use of 10 per cent. solutions of zinc chlorid, or trichloracetic acid; phenol in varying strength, Rhein's solution of mercuric chlorid in hydrogen dioxid, the essential oils, etc., have been used.

Hydrogen dioxid is not favored because, owing to its reaction with pus in a confined space, septic organisms may be forced into a deep recess beyond the reach of all remedies, defeating the attempt to establish a cure. The selected remedy is placed in the syringe, the needle heated and made to penetrate a disk of vulcanizable rubber; the needle is placed in the canal as near the apex as it can be made to go, the rubber tightly packed about it, and upon this moistened pledgets of cotton held in place by a pair of pliers. The solution is then forced through the sinus and repeated if desired. The canal is now dried and the modified formo-cresol mixture applied and allowed to remain in the canal for several days or a week. A cure should follow this treatment.

If, after a week or ten days, pus again appears upon the gum, the treatment should be repeated. This is usually followed in uncomplicated cases by a cure. The abscess cavity gradually is obliterated by granulations, which organize into cicatricial tissue, and the fistula closes. In complicated cases, such as may arise where the end of the root has been denuded of its pericementum, or resorption has occurred, leaving a roughened end, this portion of the root may have to be removed before healing is finally established.

To excise the end of the root it should be freely exposed. To do this the fistula should be incised, under strictest aseptic precautions, and the opening packed with sterilized gauze. As soon as the end of the root is freely exposed a crosscut fissure bur may be used to cut off the end projecting into the abscess cavity. It may be necessary to use root forceps to remove the incised end. The end of the root remaining should be made perfectly smooth by means of small stones or burs; the tissues in the vicinity of the cut root curet-

ted, and the cavity sprayed with an antiseptic solution and packed with gauze. The packing is to be changed daily, and, as granulations begin to fill the abscess cavity, less and less of the packing will be required, until the wound completely heals.

In place of root excision some operators resort to extraction and replantation in chronic abscesses which fail to respond to what may be denominated the *antiseptic plan* of treatment. Many successes have been reported, especially in single-rooted teeth. The procedure is as follows: The patient's mouth is sprayed with a suitable antiseptic solution, the tooth extracted and placed in a 1-1,000 bichlorid solution. The canal is thoroughly cleansed through its apical end and filled with oxychlorid of zinc. Its denuded end may be cut off, the end of the root smoothed, and the opening permanently closed with temporary stopping. The socket from which the tooth has been removed should be sprayed with a suitable antiseptic solution, dried, again flooded with alcohol, and the tooth returned to its socket and held in place by means of ligatures, or other mechanical device.

As has been noted, antral empyema is commonly caused by an apical abscess. The patient is disturbed by offensive discharges into the nasal cavity on the side of the affected antrum, complains of neuralgic pains in the head and face associated with a feeling of fullness. If the patient be placed in a darkened room and an electric mirror introduced into the mouth, the affected side with its *dullness* will stand in strong contrast to the *clearness* of the opposite side. Little difficulty is usually encountered in isolating the tooth underlying the complication, and its removal is followed by a purulent discharge from the antrum. The opening leading into the antrum should be enlarged to facilitate irrigation and drainage. It is

well here, also, to avoid the use of hydrogen dioxid for similar reasons to those which exclude its use in the treatment of chronic apical abscess.

More recently the bismuth-vaselin paste, introduced by Dr. Emil Beck of Chicago, has been employed in the treatment of chronic abscesses, with apparently the same degree of success that has attended its use in the treatment of chronic pus formations in other parts of the body. After the root canal has been sterilized, a 30 per cent. subnitrate bismuth-vaselin paste is injected into the sinus, or the warm liquefied bismuth-vaselin paste may be used, as described by Dr. Rudolph Beck in his treatment of pyorrhea pockets. This paste consists of bismuth subnitrate 30 per cent., vaselin 60 per cent., paraffin 5 per cent., wax 5 per cent. The vaselin, paraffin, and wax are boiled and the bismuth added; a syringe is charged with this liquid paste, warmed, and introduced into the deepest part of the sinus. Most excellent results have followed the use of either paste both in chronic abscesses and in discharging pyorrhea pockets.

Chronic Septic Apical Pericementis (*Non-purulent*).

Definition.—A vascular disturbance of the apical pericementum associated with septic conditions, but free from pus formation, although this may at any time take place, resulting in an acute abscess.

Etiology.—Imperfect root sterilization associated with imperfect root canal filling may lead to a septic state and the consequent irritation of the apical pericementum. It has been demonstrated by many investigators that, unless canal sterilization is complete, septic organisms acting upon pulp filaments that have been allowed to remain, or serous collections entering the canal

because of imperfect root filling, may at any time inaugurate a putrefactive process with subdued consequences, but sufficient to establish an apical irritation. Highly attenuated canals, imperfectly treated, may subsequently become a cause of the disease.

Pathology and Morbid Anatomy.—The products of the putrefactive process irritate the apical tissues, inducing a vascular reaction which, perhaps, from the restricted nature of the process, or perhaps from the nature of the organisms present, assumes the character of a *low grade* inflammation. An acute apical abscess may at any time follow the non-purulent pericementitis, providing pyogenic organisms reach the area and set up an acute process. The vascular reaction in the apical area is followed by a tenderness upon pressure and slight looseness. The gum color also shows the effect of the underlying hyperemia.

Symptoms.— These are of the same class, as a rule, as those characteristic of pericemental diseases. Tenderness upon pressure, but not the acute or general tenderness noted in the acute diseases; usually the tenderness is disclosed only upon pressure in one direction. The tooth moves more easily in its socket than the adjoining teeth, and the gum overlying the root is more deeply red. The tooth also shows evidence, in its opacity, of pulp devitalization.

Diagnosis.—The symptoms of several diseases of the pericementum may resemble those of chronic septic non-purulent pericementitis. It is to be differentiated from a pericementitis induced by malocclusion, or a *mild* traumatism, or possibly root resorption. If malocclusion is suspected it is corrected, and if the symptoms of tenderness upon pressure and looseness disappear the diagnosis is complete. If a *mild* traumatism is respon-

sible for the pericemental affection the history of the case usually reveals this; or rest to the affected tooth for a day or two, with counterirritants to the gum, effects a cure. Root resorption is rarely diagnosed, excepting with the aid of the X-ray.

Therapeutics.—In the treatment of chronic septic non-purulent apical pericementitis the procedure is similar to the plan of treatment of moist gangrene of the pulp. The crown is made sterile with alcohol and the dam adjusted. The canals are opened and explored to their apices. This is imperative if a cure is to be made. The modified formo-cresol mixture upon cotton is placed in each canal and Tr. iodin applied to the gum. If the canals have been opened to their apices, and if no complication exists at the ends of the roots, one application of the modified formo-cresol mixture may suffice to destroy all septic substances present; if not, a second application usually suffices. The return of the normal gum color, the disappearance of the tenderness upon pressure, also the looseness, indicate the eradication of all irritants and the establishment of a comparatively normal condition.

Class 2—Non-septic Pericementitis

Definition.—Vascular disturbances frequently not exceeding hyperemia in the apical region, or involving more or less completely the entire pericementum, and occurring as the result of non-septic causes. These diseases occur both as acute and chronic affections. For descriptive purposes these affections of the pericementum may be viewed according to their causes, either *local* or *systemic.* The local causes include *injuries, drug action through the canal, perforation, resorption of roots, hypercementosis,* etc. The systemic causes include such

systemic conditions as *gout, syphilis,* or the action of *drugs* taken internally.

Traumatic Pericementitis

Definition.—A vascular disturbance of the pericementum resulting from an injury.

Etiology.—Traumatic pericementitis may be caused by any agent acting with a degree of intensity sufficient to alter the blood supply of the pericementum and establish pain upon pressure and looseness of the tooth. This may be a blow, excessive malleting, biting upon hard substances, excessive wedging, faulty occlusion, the action of drugs, also of orthodontic appliances, etc. In many instances the cause is avoidable. This is especially so in the many injuries to the pericementum that follow the attempt to crush hard objects between the teeth. If patients were fully impressed with the great force necessary to crush hard objects and the injury that might follow such attempts, many accidents, some of which result in loss of teeth, could easily be avoided. Excessive malleting made necessary in large gold restorations has almost ceased to be a factor of pericemental disturbances in the present inlay method of making these repairs. Too much emphasis cannot be laid upon the irreparable injury to the pericementum that follows poorly fitting bands associated with crown and bridge work; also the irritation resulting from a band that has been forced a too great distance upon the root. Excessive and rapid wedging painfully irritates the pericementum, and in many instances makes an enforced rest necessary before the operation can be completed. The use of irritating agents in the canal, such as formalin in strong solutions, sodium dioxid, zinc chlorid, etc., may provoke

serious pericemental irritation; so, too, with the use of arsenic for devitalization, a serious complication may arise, demanding the utmost care for its successful elimination. Root canal fillings extending through the apex almost always are followed by pericemental disturbances, in some of which extra deposits of cementum occur; in others resorption is in evidence.

Pathology and Morbid Anatomy.—Any of the aforementioned causes acting upon the pericementum induce hyperemic changes. If the cause is not removed constructive changes may take place, and finally a low grade inflammation may assert itself, followed by resorption. In the chronic cases excessive tissue degeneration occurs. A gnawing pain is referred to the tooth; when pressed upon a tenderness is disclosed; the tooth is somewhat loosened. If an acute traumatism presents, the result of biting upon a hard substance, or a blow, an acute response is elicited upon pressure upon the injured pericementum. The inflammatory phenomena depend upon the intensity of the action of the cause, but in all cases evidence of inflammatory exudate and cellular emigration may be noted. In some cases injury to the apical vessels is followed by thrombosis and death of the pulp, and still later by moist gangrene and apical abscess.

Symptoms.—The symptoms are those of pericementitis modified by the intensity of the action of the cause. The tooth responds to pressure—not in the acute manner observed in an acute septic pericementitis. It is also somewhat loosened, and the gum color is slightly altered.

Diagnosis.—The exclusion of septic causes and a knowledge of the case, or its history, may be the means of making a correct diagnosis. But in no instance can we be assured of this unless the treatment and its re-

sult verify the assumed diagnosis. The X-ray may be the means at times of reaching an accurate diagnosis.

Therapeutics.—The cause must be determined and removed if possible. If the pericementum has been injured in biting upon hard substances, the tooth should be afforded rest by placing a cap upon, or by adding to an occlusal filling of, the adjoining tooth. Counter-irritation will also be helpful in these cases. If the cause lies in poorly fitting crowns, these must be removed, the root or tooth remain crownless until the pericementum recovers, when a properly adjusted crown should be made. Root fillings or instruments extending through the apex will require removal, which in some instances will enforce root amputation prior to the disappearance of the symptoms of pericementitis. In cases of perforation root amputation may be practiced as a last resort, or the tooth may be extracted, the perforation obliterated by filling, and the tooth replaced. Tr. iodin upon the gum is helpful in all cases. Apical irritation resulting from irritating drugs applied in the canal may be controlled by the use of the various anodynes, singly or united; the menthol-thymol-phenol combination is excellent; the extract of hamamelis will be found useful, either as a wash diluted one-half, or used full strength in the root canal to allay apical irritation.

Hypercementosis

Synonyms.—*Exostosis, Cementosis, Hyperplasia of the cementum.* The condition has also been called *hypertrophy of the cementum;* this is incorrect, as pointed out by Hopewell-Smith, as the condition is the result of an "inflammatory thickening of the tissue," and not to the increase in size of the structural elements of the cementum.

Definition.—Hypercementosis, or hyperplasia of the cementum, is an overgrowth of the cementum due to the

FIG. 86.—HYPERCEMENTOSIS. (Burchard.)

increase in the tissue elements resulting from an increased functional activity of the cells of the pericementum.

Etiology.—Under the influence of various forms of chronic irritations the pericementum becomes hyperemic. An exudation takes place, which later organizes into fibrous tissue, into which cemental deposits are made. This may originate from protruding root canal fillings, malocclusion, metallic fillings impinging upon the cementum, and a variety of other causes competent to increase the "functional activity of the cells of the periodontal membrane under the influence of the inflammation of chronic periostitis" (Hopewell-Smith).

Pathology and Morbid Anatomy.—The new growth which may occur at the end of the root or upon the sides, or as a mere spot scarcely visible, differs from the normal cement in possessing irregular lacunæ and canaliculi. If, as claimed by Hopewell-Smith, the original cement formation is devoid of these features, and an important histological difference between the original formation and the hyperplasia exists, the deposits are made in the fibrous tissue which has formed from the inflammatory products. The popular view that the condition does not surpass in any sense a mild constructive hyperemia

appears to be, according to Hopewell-Smith, erroneous. Burchard[1] says: "The altered physiology concerned in hypercementosis is a mild periodical irritation of a more or less localized portion of the pericementum."

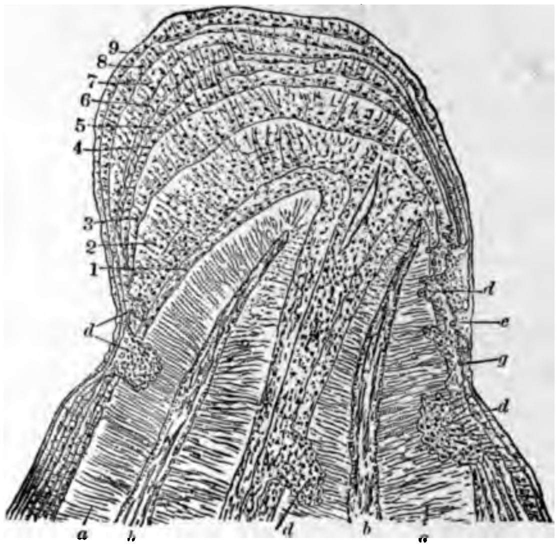

FIG. 87.—APEX OF ROOT OF AN UPPER BICUSPID TOOTH WITH IRREGULARLY DEVELOPED CEMENTUM:

a, a, dentin; *b, b,* pulp canals. The lamellæ of cementum are marked 1, 2, 3, etc.; *d, d, d,* absorption areas that have been refilled with cementum. It will be seen that the apices of the roots were originally separate, but became fused with the deposit of the second lamella of cementum, and that in this the regular growth began and was most pronounced. It has continued through the subsequent lamellæ, but in less degree. It will also be noticed that the absorption areas, *d, d, d,* have proceeded from certain lamellæ. That between the roots has broken through the first lamellæ and penetrated the dentin, and has been filled with the deposit of a second lamella. Other of the absorptions have proceeded from lamellæ which can be readily made out. The small points, *e,* seem to have been filled with the deposit of the last layer of the cementum, while others have one, two, or more layers covering them. (Black.)

The new deposits may lead to resorption of the alveolar walls, also of the intervening osseous structure, resulting in union of the roots, called *"false gemination."*[2] Black records a case (Fig. 87) in which resorption of

[1] Burchard's "Pathology and Therapeutics."
[2] Hopewell-Smith, "Patho-histology."

cementum and dentin occurred, followed by a deposition of cementum in the resorbed area. Apparently different vital processes may occur conjointly as reactions to chronic forms of irritation, such as a protruding canal filling; a cavity of decay impinging upon the cementum may lead to both hyperplasia and resorption. Or, as previously noted, the hyperplasia may lead to resorption of the alveolar walls and bone, and attach itself to the root of the adjoining tooth, resulting in "*false gemination.*" In what manner the functions of the different cells engaged in the two distinct forms of vital action may be induced is not known.

Symptoms.—No definite symptoms of the disease can be formulated. Hypercementosis may exist without any pathological indication of its presence, and, on the other hand, it may give rise to severe neuralgic manifestations, at times located in distant parts. Dr. Flagg[1] records cases of severe functional complications of the eye, ear, and other parts, apparently arising as reflex disorders from hypercementosis. Extraction of the affected root in each instance being followed by a cure of the associated disturbance. Locally the gum color remains normal, and the tooth or root is firmly fixed in its socket. A slight response to pressure is usually noted.

Diagnosis.—Without well defined symptoms an accurate diagnosis cannot be reached without difficulty. By elimination the various pulp diseases, and those of the pericementum, are negatively diagnosed, the possible hypercementosis remaining. The long period during which painful manifestations may be recalled by the patient, at first insignificant, but growing more and more severe, may be taken as corroborative of the diagnosis. The usual slight response to pressure, although this may be

[1] *Dental Cosmos*, 1878.

absent, further supports the diagnosis of pericemental involvement. In nearly all cases the diagnosis can be verified with the aid of the X-ray.

Therapeutics.—Treatment directed with the aim of conserving the tooth almost always ends in failure. However, the end may justify the attempt. If an apparent cause for the condition can be found, such as malocclusion, or lack of occlusion, or fillings impinging upon the pericementum, it should be removed. Counterirritants should be applied to the gum. An alterative may be suggested and given with the approval of the patient's physician. If this plan of treatment proves unfruitful, the tooth must be extracted. In many cases of hypercementosis the enlargement of the root makes extraction extremely difficult. Its locked condition invites fracture, the remaining end, which must be removed if relief is to be afforded, necessitating at times the removal of the overlying bone; or the alveolar walls are so severely strained as to result in an alveolitis after extraction. The pain following this is almost unbearable, and requires for its control persistent and efficient local medication, and at times only internal medication will give relief. Locally nothing exceeds in efficiency the injection of a 1 per cent. solution of cocain, preferably made in a combination of menthol, extract of hamamelis, and distilled water, as per the following:

℞	Hydrochlor. cocain	grs. v
	Menthol	grs. xx
	Ext. hamamelis	} aa ℥ss
	Water dist.	}

M. Sig.—Use 15 to 30 m. of the solution.

Internally it may be necessary to use 1/8 grain of sulph. morphia, which may be repeated in one hour.

Resorption of the Roots of Permanent Teeth

Definition.—Root resorption of the permanent teeth is a pathologic removal of the cementum and dentin of the root by multinucleated cells, which apparently have been stimulated into resorptive activity, owing to chronic irritation.

Etiology.—Any form of prolonged irritation which is capable of attracting the phagocytic cells may be associated with the phenomena of resorption. Canal fillings extending beyond the apex are commonly associated with the process. Perhaps as commonly may the effect be noted upon teeth which have been replanted, transplanted, or implanted. Caries extending upon the root frequently has been found to be related with resorption. Foreign bodies irritating the pericementum may be causative factors. In some instances no tangible cause appears to exist. That the process in these cases without apparent cause can be explained by the existence of a dyscrasia [1] does not seem well founded. It may be that the chemotactic property of the irritant offers the explanation of the process, and that in those cases in which resorption occurs without any tangible irritant the explanation may be found to be in the failure to detect a cause. Irritants floating in the blood stream may have been infiltrated into the connective tissue of the pericementum, which subsequently, by a positive chemotaxis, attracted the phagocytic cells, the essential cells in the conduct of the process.

Pathology and Morbid Anatomy.—Present knowledge concerning resorption of bone regards it as being related to resorption of other tissues, and views the leukocytes as the necessary elements of the process. "The recog-

[1] Burchard's "Pathology and Therapeutics."

nition of the nature of the osteoclasts as originating in the leukocytes may be considered as a great step in advance, as it leads one to regard many of the processes at work in the hard and soft tissues as essentially similar in nature. According to Ziegler, 'recent researches into the absorption of bone appear to place it on a level with absorption of other tissues, and to view them all from the same standpoint.' "[1] Any of the aforementioned causes may be the means of attracting the leukocytes to the field of irritation, "and these singly, or uniting together to form *giant cells,* attack and take into their interior the particles to be removed." If these cells fail to remove the foreign body connective tissue may form about it and encyst it. In the removal of bony structures these cells very likely elaborate an acid capable of effecting dissolution of bony tissue. The remaining organic matrix may be digested by these cells. In this manner any portion of the root may be removed (Fig. 88). When teeth are implanted, transplanted, or replanted, a vascular reaction occurs with its associated fibrinous exudate and corpuscular migration. The presence of the root stimulates a resorptive activity of the leukocytes and the root is removed in spots. Encystment also takes place through connective tissue formations, as well as deposits of bone, and the root in this way becomes fixed. The resorptive activity of the leukocytes may be checked and the tooth remain in position. On the other hand, if the inflammatory symptoms do not subside, bone deposition does not occur and the resorptive activity is greater.

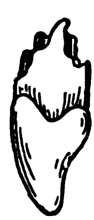

FIG. 88.—ROOT RESORPTION.

Symptoms and Diagnosis—A vague uncomfortable

[1] Hopewell-Smith, "Patho-histology."

feeling may be associated with a tooth, which may increase when pressure is made upon the affected root. These symptoms, with the loosening of the tooth, which usually is a concomitant, indicate a pericemental involvement. Within the usual lines of treatment an entrance is made into the pulp canal. If the pulp is vital it is killed and removed, and in the filling of the canal the shortened root is discovered. If the resorption occurs upon the lateral aspect of the root, every other phase of pericemental affection is eliminated excepting hyperplasia. An X-ray picture should then definitely determine the diagnosis.

Therapeutics.—If the condition is diagnosed and the cause, as, for example, a protruding canal filling, can be removed, this is done, and the condition further treated as one of aseptic pericementitis. If the annoying sensation or pain continues, the tooth must be extracted.

Systemic Non-septic Pericementitis

Definition.—An aseptic pericementitis following systemic conditions, or the effect of drugs taken internally.

Etiology.—It has been frequently observed that patients classed under the arthritic group develop a vascular disturbance of the pericementum, which can only be explained as occurring in consequence of an infiltration into the pericementum of imperfectly oxidized products characteristic of this group and occurring in other parts of the body. That uratic deposits are found upon the roots of teeth has been conclusively shown by Peirce (see Pyorrhea Alveolaris), and that these deposits are capable of exciting vascular disturbances is a well known fact. It is also well known that patients classed as *arthritic* exhibit pericemental disturbances, which readily respond to the general treatment applied in such

cases with little or no local treatment. Other toxic substances retained in the circulation expressive of malnutrition and other diseases may lead to similar pericemental disturbances. Ptomain poisoning may be cited as a disease frequently involving the roots of several or all of the teeth in serious disturbance. (In these cases the disease is of septic origin.) The local effects of such drugs as mercury, lead, potassium, iodid, etc., taken internally for a long time, are too well known to require more than passing notice.

Pathology and Morbid Anatomy.—The retention in the circulation of abnormal waste material and its subsequent deposition in the pericementum is followed by a dilatation of the arteries and an exaltation of the pericemental sensitivity, in proportion to the vascular disturbance; the veins next dilate, the tooth loosens, becomes increasingly painful upon pressure, and the overlying gum color is deepened. If the irritation continues, i. e., if the cause continues to act, a fibrinous exudate and diapedesis of the leukocytes occur. This marks a more painful period of the disease. If the condition be now taken in hand, both as to the systemic factor of the disease and the local disturbance, the symptoms usually yield promptly; but if infection takes place, a *pericemental abscess* may follow and mark a still more painful period of the disease, and one which usually ends in loss of the tooth. This is not an unusual occurrence in those cases in which the pericemental disturbance appears to be associated with the *arthritic state.*

Symptoms.—The symptoms are those of pericementitis—pain upon pressure, looseness and extrusion of the tooth, and discoloration of the overlying gum tissue. Their severity depends upon the intensity of the action of the irritant. If pyogenic infection has taken place, in-

tense throbbing pain is experienced, the gum tumefies somewhere near the apex, and finally a discharge of pus takes place. In multirooted teeth the center of the disturbance may be at the bifurcation of the roots. These cases almost always end in extraction, owing to the severity of the symptoms, frequently before a diagnosis has been reached.

Diagnosis.—The diagnosis of non-septic systemic pericementitis is usually reached without difficulty. The symptoms point to pericementitis. The translucency of the crown, the possible absence of a large filling, and the positive response to the test for pulp vitality clearly point to a systemic factor. Further questioning usually discloses a history of gout or of the internal administration of one of the drugs capable of involving the pericementum.

Therapeutics.—If the condition be a gouty manifestation proper general treatment must be accorded; for the acute pain nothing is more serviceable than the following:

℞ Aspirin .... grs. xxx
Saloli .... grs. xxx
M.—Et divid capsulæ No. xii.
Sig.—One capsule to be followed in one hour by another.

One or two capsules materially aid in controlling the pain. It is always best to consult with the patient's physician before prescribing this or any other internal remedy. Locally, rest should be afforded the affected tooth (see acute apical abscess), iodin and aconite applied to the gum tissue, and antiseptic mouth washes ordered with an insistence upon frequent usage of same. Applications of full strength lactic acid to the root of

the affected tooth will be found to be of great service. If the condition originates from drugs taken internally their further use must be inhibited, which in most instances results in a speedy return to a normal state.

Degenerations of the Pericementum

Hopewell-Smith first called attention to a fibroid degeneration of the pericementum occurring as a senilic change and characterized by an increase in the size of the pericemental fibers, the loss of their nuclei and normal structural arrangement, and the appearance of areolar spaces. That various forms of degenerations of the pericementum may arise is very likely, indeed, in view of its exposure to the great number of causative factors, both internal and local, which are capable of exciting a continued altered blood supply. A number of the local causes capable of inducing changes in the pericementum have been studied; of these the most prominent are *overuse of teeth, partial* and *complete disuse of teeth.*

Overuse of Teeth.—*Definition.*—Excessive strain, or a condition of overwork associated with one or more teeth.

Etiology.—Certain habits, such as gum or tobacco chewing, may impose a strain upon the pericementum exceeding its normal capacity. Teeth-gritting may also produce it. Excess of filling material, either proximally or occlusally, is likely to establish a state of overwork or overstrain of the pericementum productive of pathological changes. Perhaps a more common cause is the loss of two or more teeth, subjecting the remaining tooth or teeth to the work of mastication formerly shared in by all the teeth upon that side. Another prominent cause of overstrain of the pericementum is to be found

when one or more teeth are utilized as attachments in poorly planned bridgework, or in being made to serve as supports for clasp dentures.

Pathology and Morbid Anatomy.—Any of the aforementioned causes producing the condition of overwork of the pericementum first gives evidence of this by a heightened sensitivity of the pericementum, the tooth becoming tender, due to the dilatation of the arterial vessels. This is followed by a dilatation of the venous vessels with its resultant stasis. The tooth is slightly extruded and loosened. Rarely, if infection does not occur, do any of these phenomena assume an acute form. The continued disturbance of the blood supply of the pericementum and alveolar walls soon lead to their degeneration and death. The changes occurring in the pericementum owing to the chronic irritation predispose it to infection, which may take place at any time, leading to acute inflammatory and suppurative phenomena. Hyperplasia of the cementum is not an uncommon concomitant of overworked pericementi.

Symptoms.—The symptoms are those of a mild aseptic pericementitis. The tooth responds to pressure, is somewhat extruded and loosened, and the overlying gum is discolored. Alveolar resorption is also usually present.

Diagnosis.—The symptoms indicate a pericemental disturbance. The history of the case may indicate an overstrain of the pericementum associated with a habit, such as gum chewing; or a clasp fitted to a certain tooth may clearly associate the cause; or the loss of several teeth, together with the gradual development of the disturbance subsequent to the loss, usually leaves no room for doubt as to the nature of the affection.

Therapeutics.—The principle of the treatment ap-

plied in these cases is the elimination of the cause and surgical rest for the affected tooth. If these fail to lead to recovery pathological complications exist, which surely signify loss of the tooth. Medication is of secondary importance in the treatment of this affection, although usually helpful. Counterirritation by means of iodin to the gum is of service; so, too, is the application of full strength lactic acid, or 10-20 per cent. trichloracetic acid, to the root of the tooth. Antiseptic washes should be frequently employed to guard against infection.

Disuse of Teeth.—*Definition.*—Disuse of teeth implies a condition the reverse of that previously considered, viz., overuse. It may be *partial* or *complete.*

PARTIAL DISUSE OF TEETH.—*Etiology.*—When one or more teeth are lost upon the same side of the arch the defective state of the mastication upon that side induces the patient to use the more effective side, resulting in a partial disuse of the teeth situated upon the defective side. Partial disuse of teeth may also arise when certain teeth are afflicted with pyorrhea and unable to comfortably withstand the stress of mastication. In these cases the patient, in order to avoid the pain arising when pressure is made upon the diseased roots, soon establishes the habit of more actively using the teeth not diseased, and this habit may persist after the pyorrhetic condition has been eliminated. The constant usage of soft food may in time deprive the pericementi of a normal blood supply and lead to similar changes as those occurring from disuse.

Pathology and Morbid Anatomy.—Every organ of the body requires a normal blood supply for the continuance of its state of normality. An insufficient blood supply means insufficient nourishment, and is soon followed by atony, degeneration, and finally necrosis. With these

changes the resistance of the part is lowered and infective processes may be set up. Partial disuse of teeth also favors the retention of food débris and bacteria about the gum margin, followed by fermentations, and leading to gingivitis and further pathological complications, ending in loss of the tooth.

Diagnosis.—A very careful examination of the occlusal relations of the teeth, and inquiry as to the food habit of the individual and his method of mastication, usually discloses the condition of partial disuse.

Therapeutics.—The patient should be forcibly impressed with the possible pathologic sequelæ attending disuse of one or more teeth. Artificial teeth should be inserted to supply missing ones, thus perfecting the ability to masticate upon the side formerly defective. The habit of utilizing only certain teeth during mastication must be corrected, as must also the use of only soft food. Friction of the gum with the brush is a corrective therapeutic means, and the use of suitable washes to prevent oral fermentation may prevent those secondary pathologic complications that are so likely to seriously menace the conservation of the tooth.

COMPLETE DISUSE.—*Definition.*—Complete disuse signifies a condition in which a tooth or teeth perform no work whatever.

Etiology.—Complete disuse is due to the loss of the antagonizing members of a tooth. If the lost teeth are not replaced, or if the tooth so situated cannot be made to serve as an abutment in bridgework, a condition of complete disuse exists.

Pathology and Morbid Anatomy.—Teeth that perform no work soon elongate; their pericementi and the alveolar walls atrophy and degenerate. Loosening follows, and is usually accompanied by infective processes.

In many instances the pulp dies and an apical abscess may supervene. Masses of calcareous deposits usually exist, hastening alveolar resorption and predisposing to gingivitis.

Therapeutics.—If the degenerations and loss of alveolar wall have not been too great, conservation is possible, providing the tooth, or teeth, are brought into use. This necessitates either plate or crown and bridgework. The tooth, or teeth, should be freed of all deposits. Existing gingivitis should be treated by applications of astringent and antiseptic agents; the patient should be instructed to practice gum massage, and further impressed with the importance of continued oral prophylaxis. If the degeneration of the alveolar structures has proceeded to a great degree, extraction may be inevitable.

DISEASES OF THE PERICEMENTUM ORIGINATING AT THE GUM MARGIN

Diseases of the pericementum having their inception at the gum margin, as a rule, are characterized by an inflammation of the gum margin, pyogenic infection, atrophy, and necrosis of the pericementum and alveolar walls. They belong to the first division of those diseases generally classed as pyorrhea alveolaris (see Pyorrhea Alveolaris). The origin of these diseases is so clearly associated with an inflammation of the gum margin that a consideration of this affection is of primary importance.

Marginal Gingivitis

Definition.—Marginal gingivitis signifies the phenomena of inflammation occurring at the gum margin.

Etiology.—Writers appear to be in accord in classifying the causes of marginal gingivitis into *local* and *gen-*

eral. These may be subdivided into *predisposing* and *exciting.* Locally the disease may arise from unremoved food débris in which fermentation has taken place, the resultant products initiating the vascular disturbance. Salivary deposits impinging upon the gum margin, imperfectly finished fillings, poorly fitting crowns, the pressure of artificial plates, or any foreign body finding lodgment beneath the gum margin is competent to induce the disease. Of the *general causes* those associated with faulty metabolism occupy a prominent position. It is now well known that owing to faulty metabolism poisonous products are formed, capable of originating a series of pathological phenomena in the tissues throughout the body. These may also so affect the eliminating organs of the body that the normal waste products are retained in the circulation, in themselves capable of reducing the vital standard of the cells of the body. These substances may irritate the pericementum and gum margin and finally induce passive hyperemia and inflammation. Dr. Rhein reports after many examinations of hospital patients that "marginal gingivitis was an accompaniment of typhoid fever, tuberculosis, malarial disorders, acute rheumatism, pleurisy, pericarditis, and syphilis, among the acute diseases. Of chronic nutritional diseases it was commonly observed in cases of gout, diabetes, chronic rheumatism, several forms of nephritis, scurvy, chlorosis, anemia, leukemia, and pregnancy. Also in disorders of the central nervous system, and following the administration of mercury, lead, and iodin." Dr. Talbot's experiments upon dogs show that the internal administration of mercury may result in a non-septic pericementitis. Dr. Black [1] states that potassium iodid may be eliminated by the pericemental glands,

[1] "American System of Dentistry."

proven by the iodin reaction of the gingival secretion, and that its elimination is usually followed by a gingivitis. Dr. Talbot's researches emphasize the association between systemic conditions—acidosis and indicanuria (see Pyorrhea Alveolaris)—and alveolar affections, termed by him *interstitial gingivitis.*

Pathology and Morbid Anatomy.—Any of the local or general causes previously noted irritating the gum margin soon results in a passive dilatation of the vessels, stasis, and swelling. This in most cases is complicated by infection, which intensifies the vascular disturbance. The gum margin has a deep red color, is swollen, to the extent, in some cases, of covering the gingival third of the crown, is painful when pressed upon, and bleeds most easily. The pericementum and alveolar wall soon become pathologically involved, evidence of pyogenic infection is seen in the appearance of pus when pressure is made upon the margin, and unless the cause is eradicated and effective therapeusis applied the destruction of the alveolar tissues proceeds until the tooth may become hopelessly involved.

Symptoms.—The margin of the gum is swollen and of a deep red, or purplish, color. The pain and hemorrhage resulting from use of the brush leads in most cases to marked oral neglect, and the evidence of infection, which in the face of great care is likely to occur, may now be seen in the appearance of pus from beneath the inflamed margin, in a degree seriously menacing the deeper structures. "Rhein describes a serpentine line of inflammation as appearing a short distance above the margins of the gum in Bright's disease of the kidneys. He considers it pathognomonic of this disease."[1] The writers have seen a number of cases of gingivitis appear-

[1] Burchard and Inglis, "Pathology and Therapeutics."

ing in diabetics, apparently originating from the systemic disturbance, as no other cause could be assigned, without any special gingival characterizations worthy of pathognomonic distinction. However, in reference to Bright's disease this distinction may exist.

Diagnosis.—The inflamed gum border associated with salivary calculus, or projecting filling material, or an ill-fitting crown, or decomposing food débris, and the prompt recovery which follows the removal of the cause without additional therapeutic aid, clearly indicate the condition. The patient is also impressed with the bleeding resulting when pressure is made against the affected gum, which is a symptom aiding the diagnosis. Those cases originating from systemic causes are not entirely cured by local measures. The underlying etiological factor must be eliminated, if this is possible, in order to restore the normal state of the gingival margin. The absence of any local cause that might account for the gingival inflammation suggests the existence of a general underlying cause, which the history of the case usually brings to view.

Therapeutics.—The cause must be removed. If the condition is due to a local cause its removal is not, as a rule, attended with much difficulty. The parts are then sprayed with a 25 per cent. solution of any of the antiseptic combinations upon the market, one of which is usually in use in every office. This usually arrests the hemorrhage following the removal of the cause. The parts to be treated are then dried with sterilized cotton, protected from moisture, and either full strength lactic acid or 20 per cent. trichloracetic acid applied to the inflamed tissue. In the writers' experience nothing excels the therapeutic value of either agent. If the cause has been completely removed one application of either

remedy usually suffices; more than a second application is rarely necessary. The importance of maintaining a state of oral hygiene must be impressed upon the patient. To accomplish this instructions should be given as to the efficient use of the brush, carrying a suitable powder; also as to the use of suitable antiseptic washes. If the diagnosis etiologically associates the affection with a systemic condition, this must receive therapeutic attention, if the local affection is to be eliminated.

Salivary and Serumal Calculus

Definition.—Calcareous deposits found upon different surfaces of the crown, also upon the roots of teeth, and apparently derived from the saliva and the serum of the blood.

Salivary Calculus (Ptyalogenic Calculus)

Definition.—Calcareous deposits consisting of the calcium salts of the saliva in combination with organic substances, usually mucin, and found most abundantly in situations approximating the ducts of outlet of the salivary glands. Two varieties are distinguished: (1) The soft, friable, whitish-yellow deposits found upon the buccal surfaces of the superior molars and upon the lingual surfaces of the inferior incisors and cuspids; (2) dark deposits, much harder than the first variety, found more frequently upon the inferior teeth.[1]

Etiology.—The cause or causes which may lead to the formation of salivary calculus are not clearly determined. In the *Cosmos*, October, 1895, Dr. Burchard quotes Dr. Kirk as follows:

"I believe all these calculary deposits will be found

[1] Burchard's "Pathology and Therapeutics."

to belong to one great order; that salivary calculi will be found to be one group of several chemical bodies which are formed by the precipitation of lime salts in colloid media, and this is the common factor in the formation of calculi in general; that about a nidus these substances will be deposited or formed in some definite manner; that they are more than mere agglomerations of lime salts with extraneous matters; that they resemble calcoglobulin more than they do mere cemented precipitates, and I believe all calculi will have a family similarity in general structure, no matter in what part of the body they are formed."

Ziegler[1] states that all free concretions have an organic basis or nucleus. The views of Rainey and Harting quite conclusively show the formation of calcoglobulin to be due to the union between calcium salts and a solution of albumin. In the formation of salivary calculus we have the deposition of lime salts from the saliva in a colloid medium, and, while it cannot be definitely stated to fully meet the conditions under which calcoglobulin is formed, there is certainly a strong resemblance to it.

Dr. Burchard in the *Cosmos,* 1895, reports experiments and expresses the view that salivary calculus is due to the action of lactic acid upon the salivary and oral secretions, forming a coagulum of mucin in which are deposited precipitated lime salts, mainly lactophosphate. Another source of addition Dr. Burchard believes to be due to the escape of carbon dioxid upon exposure of the salivary secretion to the air; the carbon dioxid holds the calcium salts in solution, but upon its escape on exposure precipitation of the calcium salts occurs.

[1] "Pathology."

In a paper by Dr. G. V. Black appearing in *Items of Interest*, June, 1911, speaking of calcareous formations, doubt is expressed as to the correctness of this theory offered by Dr. Burchard. Dr. Black's investigations appear to show that the deposition of the salts occurs because of the presence of a substance he calls *agglutinin* (not the agglutinin discussed in bacteriology), being an agglutinating substance. Fig. 89 illustrates this substance discovered by Dr. Black. This investigator also expresses the view that the formation is due to a positive chemotaxis between the salts in the solution and the deposited agglutinin, or globulin. The agglutinating substance Dr. Black believes to be secreted with the formed saliva, or elaborated at once when the saliva leaves the ducts. He furthermore expresses the view that the agglutinating substance arises as the result of faulty metabolism. Dr. Burchard[1] writes: "That the deposit of calculus is mainly dependent upon the superabundance of calcium salts in the saliva is evidenced by the fact that in young children but little calculus is depos-

Fig. 89.—Photomicrograph of Agglutinin of Salivary Calculus Moderately Well Filled with Calcium Salts, but Very Soft.

It was pressed down under a cover-glass in a thick solution of shellac in alcohol, after thirty minutes in alcohol to remove water. The general appearance of globules is fairly well seen. 1½ inch lens, 4½ foot bellows. (After Dr. Black.)

[1] Burchard's "Pathology."

ited upon the teeth, though the oral fermentation is not lacking.''

In the paper by Dr. Black previously referred to he expresses his belief that the formation of calculus is not dependent ''upon the presence of more or less calcium salts in the blood, body cells, body juices, or secretions.'' ''The amount of calcium salts may become abnormally large or small, possibly, in a given secretion, and yet not be a factor of consequence in the deposit of any of the oral calculi.'' ''This deposit will depend primarily on the formation and deposit of the agglutinating substance in which the precipitated particles are caught and held.''

Fig. 90 shows the laminated structure of calculus; the laminations may represent periods of activity. In nearly all cases of salivary deposits evidence of putrefaction is present in the existence of offensive odors. This indicates that bacteria become entangled in the formation, and that sufficient free organic matter is present to admit of its putrefactive dissolution by the imprisoned bacteria.

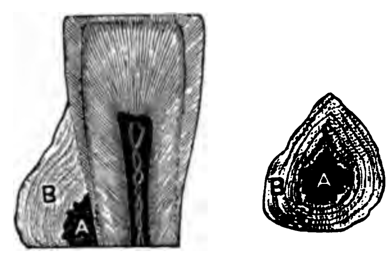

FIG. 90.—A, NIDUS; B, CALCULUS. (Burchard.)

Composition of Salivary Calculus.—Harlan, ''American System of Dentistry,'' quoting Schehvetskey, gives the following analysis:

Water and organic matter	22.07
Magnesium phosphate	1.07
Calcium phosphate	67.18
Calcium carbonate	8.13
Calcium fluorid	1.55

Dr. Talbot gives the analysis of Stevenson, as follows:

Water and organic matter.........	21.48
Magnesium phosphate	1.31
Calcium phosphate with a little carbonate and a trace of fluorid.....	77.21

These two analyses differ but slightly. They both show that salivary calculus consists of over 77 parts of inorganics, 67 parts of which is the calcium phosphate, the remaining 10 parts consisting of the carbonate and fluorid of calcium, in the proportion of about 8½ parts of the former to 1½ parts of the latter. This has a bearing upon the contention occasionally made, without scientific data for its basis, that salivary calculus is formed through combination of carbon dioxid exhaled in respiration with the calcium salts of the saliva, forming calcium carbonate, and being deposited in the situations in which calculus is generally found. If this were so salivary calculus would consist largely of calcium carbonate, which is not what its chemical analysis reveals.

Pathological Effects.—Deposits of salivary calculi act as irritants to the gum margin, inducing hyperemia, stasis, and its catarrhal accompaniment. This condition favors infection, which usually takes place, resulting in a more serious vascular disturbance of the gum margin, and frequently in pus formation. In some instances, usually those in which the hygienic measures have been practiced by the patient, aided by what may be termed the resistance of the oral mucous membrane and gum tissue, infection of the gum margin does not take place, but a progressive resorption of the alveolar wall and loosening of the tooth are noted, and this may continue until the tooth can be removed with the fingers. In those

cases in which infection occurs and pus forms, the phenomena are those of pyorrhea alveolaris. The toxic substances elaborated beneath the gum border may enter the stomach and intestines and not only pathologically involve the alimentary canal, but they may gain entrance into the circulation and seriously menace other organs of the body. It is now quite well recognized that salivary calculus with its consequent marginal gingivitis and generally present pus may be the causative antecedent to a number of morbid phenomena, seriously threatening the health of the patient.

Therapeutics.—The first step in the treatment is to spray the mouth with a suitable antiseptic solution, in order to remove as much foreign substance as this means may allow. For this purpose a 25 per cent. solution of hydrogen dioxid forced under a 25-pound pressure over the gum tissue and teeth, and held in the mouth for fully two, or still better, three, minutes, and followed by a 25 per cent. solution of any one of the many antiseptic combinations upon the market, much, if not all, of the infective matter formed beneath and around the margin is eliminated from the field of operation, and the danger of carrying septic organisms into the deeper tissue during the removal of the deposits is materially lessened.

The next step is the removal of the deposits. For this purpose many instruments have been devised. Most operators soon profess a preference for certain forms which in their hands appear most effective. It is useless to describe instruments and methods of their employment for the removal of calculi, when the personal equation plays so important a part in this operation. The important desideratum is that all particles must be removed from around and beneath the margin, and the effort must

be continued until a perfectly smooth surface is finally formed.

If the gum margin has not been seriously disturbed the removal of the deposits and the use of an antiseptic wash usually suffice to establish its normal state; but if evidence of inflammation exists it is better to apply either lactic or trichloracetic acid, as recommended in the treatment of *marginal gingivitis*. If, through loss of the alveolar wall, the tooth or teeth are loosened, a suitable splint (see Pyorrhea Alveolaris) should be constructed. The patient must also be impressed with the importance of periodic examinations and treatments in order to prevent excessive redepositions.

Previous to Dr. Black's recent investigations no mention has been made of internal medication as a means of abating these formations. Dr. Black reports that, when he observed the formation of calculus to be rapid, a saline cathartic within a few hours would control the formation for a period of one to four weeks. The inference, however, must not be drawn from this that constipation is an etiological factor in calcareous formations. Dr. Black entertains the view that the formations more likely depend upon the formation of a larger amount of chyle than can be assimilated, and that this leads to a faulty metabolism in which the agglutinating substance is formed and deposited from the secretions. The cathartic by increasing elimination tends to correct this.

Serumal Calculus (Sanguinary Calculus)

Definition. Deposits found upon the roots of teeth at a point between the gum margin and apex of the root and derived from the serum of the blood. Writers[1]

[1] Burchard and Inglis, "Pathology and Therapeutics."

distinguish several varieties of serumal calculus: (1) subgingival calculus, a variety apparently associated with an altered secretion from the gum margin in the presence of fermentation; (2) a variety associated with a chronic pus formation, called pyogenic calculus; (3) a variety found near the apex of the root associated with the gouty diathesis, and found by Peirce to consist of uratic salts, called by him hematogenic calculus. It is questionable whether in the state of our present knowledge we are justified in naming pyogenic calculus as a separate and distinct formation. In other words, if a variety of calculus formation originates in the presence of a septic process, the first and second divisions of the

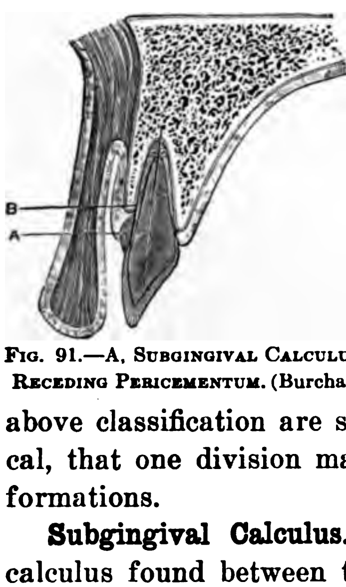

FIG. 91.—A, SUBGINGIVAL CALCULUS B, RECEDING PERICEMENTUM. (Burchard.)

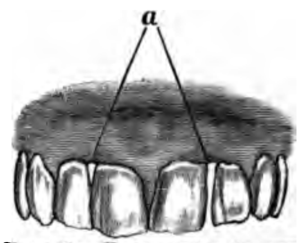

FIG. 92.—RESORPTION OF THE SEPTUM OF BONE AND RECESSION OF THE GUM BETWEEN THE CENTRAL AND LATERAL INCISORS: Caused by deposits of serumal calculus under the gingivæ. (Black.)

above classification are so closely related, if not identical, that one division may be made to include all such formations.

Subgingival Calculus.—*Definition.*—A formation of calculus found between the gum margin and the tooth, much darker than salivary calculus, usually formed in small smooth masses.

Etiology.—Subgingival calculus (Figs. 91 and 92) appears to be due to the retention of food débris at the gum margin, which undergoes fermentation, inducing an

irritation of the gum margin and a precipitation of the calcium salts contained in its secretion. Exact knowledge as to the cause of this formation is not at hand. Another possible explanation as to its etiology is that it represents an effort of the gum margin to eliminate waste products from the system.[1] The more likely explanation is the former. The presence of fermentation at the gum border is followed by a vascular disturbance in the gum tissue and an alteration in its secretion. It is likely that, as a result of the vascular disturbance, a serous exudate occurs; the calcium salts of the blood are now in direct contact with a mass of organic matter in a state of fermentation. A reaction between the two is not unlikely, with its resultant calcareous formation.

Pathological Effects.—These are similar to those of the ptyalogenic calculus. Resorption of the alveolar process occurs and the tooth loosens. The gum margin becomes hyperemic, infection usually follows, and the phenomena of inflammation are in evidence. Unless remedial measures are applied the pericementum and alveolar wall are progressively destroyed, and the tooth may finally be lifted from the socket with the fingers.

Therapeutics.—The treatment also is similar to that of ptyalogenic calculus. The deposits must be removed. In many instances this proves to be corrective of further pathological effects. Prior to the removal of the deposits the gum margins should be sprayed as suggested in the treatment of ptyalogenic calculus. After the removal of the deposits, lactic acid, or 20 per cent. trichloracetic acid, is to be applied to the inflamed tissue. If the deposits have been thoroughly removed one application of either agent usually suffices to reduce the inflammation. The importance of future prophylaxis

[1] Burchard and Inglis, "Pathology and Therapeutics."

treatments must be impressed upon the patient. In Dr. Black's recent investigations, previously reported, he does not view with favor the use of medicines or antiseptics in the treatment of the pathological effects of calculus. He recommends the removal of all deposits and the irrigation of the pockets with normal salt solution. A reduced diet may also prove beneficial. The restrictions as to the local use of the commonly accepted remedies generally utilized in the treatment of these conditions, originating from so high an authority as Dr. Black, will surely impress themselves upon the members of the profession.

Hematogenic Calculus.—*Definition.*—A formation of calculus usually found near the apex of the root, occurring in those individuals fittingly classed as "gouty," in consequence of the excessive retention in the blood of those salts characteristic of this class of patients.

Etiology.—The clinical association of certain well defined pathological states with those types of faulty metabolism characterized by an excess of uric acid in the blood, and its deposition in the form of urates throughout the body, have been fully considered by many writers. Whether the excess of uric acid is due to insufficient oxidation or an excess of nitrogenous or starchy food, the products of which are imperfectly oxidized by the cells, or which may derange the hepatic functions, or to reduced elimination of waste substances, is not the important question here to be discussed. The fact remains that uratic salts are deposited in various tissues and joints, and that such deposition may take place in the pericementum, as has been demonstrated by Peirce; calculi scraped from the roots of teeth in which the gum margin remained intact responded to the murexid test, showing the presence of urates in the deposits. It must

not be understood that the entire deposit consists of uratic salts; these only form a part of the deposit, and are combined with calcium phosphate. But the distinctive feature of these deposits is their etiological association with the gouty diathesis. For the pathological effects and therapeutics of hematogenic calculus the reader is referred to chapters on Pyorrhea Alveolaris and Pericemental Abscess.

PERICEMENTAL ABSCESS (GOUTY ABSCESS)

Definition.—Inflammatory phenomena appearing upon the lateral portion of the pericementum, in a circumscribed area, terminating in a purulent or non-purulent discharge through the overlying gum, or at the gingival margin. It usually occurs upon the roots of teeth containing vital pulps. When the discharge does not contain pus the term abscess is obviously incorrect.

Etiology.—As early as 1874 Dr. Darby noted this affection, and since then Marshall, D. D. Smith, Kirk, and others have described cases under their observation. Kirk [1] regards the disease as originating from autointoxication, either as the result of toxic substances arising from abnormal nutritional processes, or as the result of the action of saprophytic bacteria within the intestinal canal. The same writer [2] has found the diplococcus pneumoniæ in pure culture in pericemental abscesses when first opened, but the claim is not made that the disease is specifically due to the action of this or any other organism. That this organism or others capable of forming pus may enter the region disturbed through deposition of toxic substances arising as previously indicated, and thus find a favorable site for their

[1] *Cosmos*, 1898.
[2] *Cosmos*, 1900.

activity, is a rational conclusion, and the more common appearance of this disease in the so-called *"gouty individuals"* strengthens the view that the disturbed regional vascularity of the pericementum is due to an infiltration of uratic salts, and the subsequent invasion of the affected area by pyogenic organisms, is the factor commonly responsible for pericemental abscess. The appearance of this disease, in a number of instances following a condition of autointoxication, the result of digestive disturbances, emphasizes as a probable cause of pericemental abscess the absorption of toxic substances formed in the intestinal canal through the agency of saprophytic germs, and the subsequent irritative action of these toxic substances upon the pericementum. Some observers hold the view that the disease under consideration originates from toxins formed in the mouth, and that these, entering the intestinal tract, are absorbed into the circulation and carried to the pericementum, or that the toxins are formed in the intestines by bacteria carried from the mouth into the intestinal tract.

Pathology and Morbid Anatomy.—Corroborative evidence is at hand in support of the view that the gouty condition is directly responsible for certain diseases of the pulp and pericementum. No valid reason can be assigned why the irritative substances floating in the blood stream, characteristic of the gouty state, may not become pathologically related to the root of the tooth, as they are with other joints of the body. Gout has been spoken of as "the disease of the rich," induced by overindulgence and lack of exercise. Lack of exercise leads to a diminished vascularity and sluggish circulation. A sluggish circulation favors gouty deposits. If from any cause, such as insufficient use, for exam-

ple, the vascularity of the pericementum is diminished, changes may occur in its tissues, favorable to gouty deposits. If the deposition occurs, hyperemia and later inflammation follows; subsequently pyogenic infection takes place, the infecting organisms reaching the affected area through the circulation, or possibly from the gum margin through the pericemental glands of Black. If infection does not occur the inflammatory exudate coagulates, degeneration and necrosis of parts of the affected tissues take place, and finally a discharge resembling the white of an egg occurs. Strictly speaking, this is not an abscess, as it contains no pus, but the condition is known under the term of "pericemental abscess."

The discharge occurs, as a rule, through the gum directly overlying the affected area, although it may occur at the gum margin, and if pus is present the condition resembles a pyorrhea alveolaris with a chronic pus-discharging surface. Continued pus formation leads to extensive necrosis of pericementum and alveolar wall, as well as to further depositions of calculi which cover the original uratic deposits. In some instances the inflammatory symptoms quickly subside with the discharge and the tooth apparently returns to a normal state. These may be the cases in which infection does not occur, and the toxic substance is removed in the inflammatory process which its deposition excited. Dr. Kirk expresses the view that the inflammatory phenomena occurring in pericemental abscess take place within the structure of the pericementum, and not beneath it, as may be said of the apical abscess. Dr. Burchard[1] reports the following case (Fig. 93). A tooth extracted during an acute inflammatory attack exhibited these significant features. The apical pericementum was intact,

[1] Burchard's "Pathology."

as was also that portion toward the gingival margin; between the two was an area of denudation in which loosely attached to the root was a rough, irregular calculus.

Symptoms.—The patient complains of pain, at first not acute, usually referred to a certain definite region, which in most cases relates to a vital tooth; the tooth responds to pressure, so that the accustomed association of pericemental involvement with infective material from the canal makes the symptom of pulp vitality here appear unusual. If the disease appears upon a non-vital tooth, the opening, which is at once made into the canal, affords no relief, whereas in the septic cases relief invariably follows this treatment. The pain grows more severe in proportion to the vascular disturbance, and the response to pressure is greatest in the direction of the affected portion of the pericementum. At no time is the response to pressure upon the tooth as severe as may be noted in the acute stage of an apical abscess, nor is the overlying gum as deeply or as extensively discolored. The pain may continue for several days or a week, when finally a circumscribed swelling appears upon the gum, bursts, and discharges a glairy fluid or pus. The discharge may take place at the gum margin, in which case there is a previous change in position of the tooth, which may appear as the first symptom of the disease. In multirooted teeth the affection occasionally appears in the bifurcation of the roots, and usually presents severe pathological manifestations.

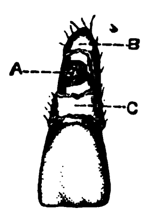

Fig. 93.—A. Calculus in Area of Necrosis; B and C, Vitæ Pericementum (Burchard.)


Fig. 94.—Pericemental Abscess.

Diagnosis.—The diagnosis of pericemental abscess, in the early stages, is not easily made. The tenderness upon pressure and the slight extrusion of the tooth at once suggest a pericemental involvement, but its exact nature is not at once made clear by the existing symptoms. The vital state of the pulp eliminates from the field of possible diseases that of apical abscess, in which condition the symptoms are also more acute than those of pericemental abscess. Is the condition a *traumatic pericementitis?* Unless a positive history can be obtained, one way or another, it may be difficult to exclude either disease in the early stages. This applies only to the early stage of the disease; later in pericemental abscess it is found that the applied therapeusis has not been productive of relief; in fact, the symptoms grow more severe until the abscess discharges. In traumatic pericementitis rest to the affected pericementum and counterirritation usually prove materially helpful, and the symptoms subside, unless the affected tissue has become infected, in which case the symptoms grow far more acute than those of pericemental abscess. After three or four days the existing doubt should give way to a definite recognition of the disease, which subsequently is confirmed by the discharge, the rapid amelioration of the case following the discharge.

Prognosis.—This depends upon the cause and the complications that may have developed during its operation, as, for example, infection; or the conditions that may have been present prior to the inception of the disease, as, for example, an existing pyorrhea; in these instances the prognosis is not favorable, nor is the prognosis as favorable when the seat of the disease is located in the bifurcation of multirooted teeth, as it is when located upon the side of the root of single or multirooted

teeth. In those cases in which the discharge takes place through the gum, and the affected area remains non-infected, a probably favorable prognosis may be given.

Therapeutics.—If the diagnosis has been made, and of this we cannot be assured until the discharge through the gum has occurred, or unless an X-ray picture may definitely determine the condition, the treatment prior to our ability to accurately make the diagnosis is palliative. Aconite and iodin to the gum, witch hazel in one-half dilution, frequently held in the mouth, may in a measure allay the pain. As the symptoms indicate a probable inflammation, a saline cathartic may be advised. In these cases this may be of double service. The condition may be etiologically associated with an intestinal toxemia, and flushing the intestinal tract will remove toxic products located there; furthermore, its use results in derivation, which also may be of value in reducing the local inflammatory phenomena.

The appearance of the swelling upon the gum, somewhere between the gum margin and the apex of the root, together with the evidence priorly determined, now clearly indicate the nature of the affection, as well as the treatment. The teeth and gum should be effectively sprayed with a 25 per cent. solution of one of the well known antiseptic solutions; the part to be incised should be wiped with cotton well saturated with alcohol, dried, and an incision made through the swelling. Burchard[1] advises the raising of a semicircular flap of gum, as shown in the accompanying illustration (Fig.

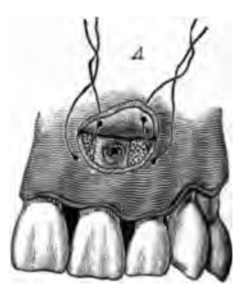

FIG. 95.—A, CALCULUS. (Burchard.)

[1] Burchard's "Pathology and Therapeutics."

95). This does not appear necessary, excepting, perhaps, in those cases in which the discharge shows the presence of pyogenic infection, and it may be deemed advisable to remove an area of necrotic tissue to facilitate the germicidal treatment. If the discharge is non-purulent, a 15 per cent. solution of trichloracetic acid is applied to the affected area, and with suitable instruments the part is thoroughly curetted; the opening is then irrigated with the antiseptic solution, preferably heated to about 110° F., dried, and the gum painted with steresol, the preparation introduced by Berlioz, which consists of the following:[1]

Purified gum lac..............	270 gms.
Purified benzoin	10 gms.
Balsam of tolu................	10 gms.
Phenol	100 gms.
Oil Chinese cinnamon..........	6 gms.
Saccharin	6 gms.
Alcohol q. s. to make..........	1 liter

This affords a varnish-like covering to the gum, with marked antiseptic properties, and remains in place for about 24 hours. Whether the cause of pericemental abscess is a deposit of uratic salts, associated with a gouty state of the patient, or whether toxins formed in the intestinal tract, due in part to abnormal food habits, absorbed, and carried to the pericementum, so diminishes its vital status as to finally induce the disease, the local treatment should be supplemented by constitutional treatment which will improve nutrition and remove toxic substances from the circulation.

[1] *Dental Cosmos*, 1895.

CHAPTER XVI

THE CONSERVATION OF THE DENTAL PULP

Definition.—Conservation of the dental pulp implies the attempt at its vital preservation when exposed, or nearly exposed, either as the result of cavity preparation, the penetration of the carious process, or when involved by any other factor which may threaten its vitality.

In the chapter on "Diseases of the Dental Pulp" it will be found that only in the instance of *arterial hyperemia* is it deemed advisable to attempt the vital preservation of the pulp, as it is rarely successfully performed in the more serious vascular disturbances which may affect the organ, and not always in dealing with the pulp in a state of arterial hyperemia. In order to better comprehend the positive, or negative, conclusion concerning pulp conservation, it may be well to consider three factors which, related to the condition of the pulp under which we may be called upon to conclude one way or the other, may determine the plan of treatment to be followed. These factors are its *structure, function,* and *pathologic tendencies.*

Structure of the Pulp.—The pulp consists of a mass of cells imbedded in a matrix of modified protoplasm in which are found supporting connective tissue fibers. Upon the surface we find the layer of odontoblasts, the dentin forming cells. When the dentin is fully formed it surrounds the pulp upon all sides, excepting at the minute apical opening, and protects the soft tissue from

compression and other forms of irritants. The pulp is what remains of the *papilla,* the formative organ of the dentin and pulp, and is neither removed by resorption nor is it physically altered to withstand compression, as may be noted in relation to other formative organs of the body. The pulp is richly supplied with blood by vessels entering through the apical foramen. The veins also pass through the minute apical opening. This is an important anatomical feature of the pulp, which easily explains the extreme difficulty with which even slight vascular disturbances are corrected. When from any cause the arterial vessels become dilated, unless the dilatation is quickly reduced, compression of the veins follows, interfering with the return of the blood from the pulp and ending in passive engorgement. This also results in compression of the arterial vessels, at the apical end, and an interference with the nourishment of the pulp. Its normal nutritive supply is now cut off, while the retention of waste substances also occurs. The absence of lymphatics from the pulp allows of the retention of irritating products, which otherwise might be removed through this channel, although if a complete blockade existed at the apical end no service could be performed by the lymphatics.

In a paper presented before the Third, Fourth, and Fifth District Dental Societies, October, 1907, Dr. L. M. Waugh, of Buffalo, calls attention to the fact that "disturbances of the dental pulp are more destructive than in tissues of the body in general." He gives the following four reasons in explanation thereof:

1. It is not a perfect tissue formation.
2. It is encased within unyielding walls.
3. Physical peculiarities in the blood supply.
4. The absence of lymphatics.

These facts are important in considering the vital preservation of the pulp.

Function of the Pulp.—The pulp is what remains of the papilla as the dentin is formed. It is the medium through which nutritive material is brought to the odontoblasts to complete dentin formation. The process of dentin formation goes on for some time after the eruption of a tooth, and until this period has been passed the importance of its vital preservation is obvious. In a general way, between twenty and twenty-five years of age may be regarded as the period denoting complete dentin formation. After this period its chief function, according to some writers, appears to be in behalf of *secondary formations,* which take place at the expense of the normal aspect of the pulp and its canal, in many instances reducing the size of the pulp to that of a thread, and almost obliterating the canal. This physical impairment also implies its functional impairment, so that when these changes occur its vital retention is not as important as it should be viewed prior to these changes. The relation which the pulp bears to the *translucent* appearance of the tooth is a factor, with many, for the preservation of the pulp, when for esthetic reasons the *translucent* effect of the crown is of prime importance.

Does the function of the dental pulp cease with the formation of the dentin, and its continued vital maintenance? Dr. Jack, in the "American Text-book of Operative Dentistry," writes as follows: "As the dental pulp by its supply of nutritive pabulum maintains the vitality of the dentin, and *increases the resisting power of the tooth,*" etc.

Dr. R. R. Andrews,[1] in replying to the query, "Is

[1] *Items of Interest,* 1901.

the Dental Pulp Necessary in the Teeth of the Adult?" writes as follows: "Now it is a matter of fact, known to all of us, that the dental pulp with its network of living tissue *does* play a very important part concerning their health, beauty, and preservation; and resists in a measure, by reason of its vital action, the inroads of infection."

Dr. G. V. Black, in the same journal, in answer to the above query, writes as follows: "I am of the opinion that the pulp of a tooth should never be destroyed except where conditions present which seriously threaten its life, or render its death in the near future certain." These writers imply a function of the pulp beyond that of dentin formation, a sort of protective influence arising from the continued *vital state* of the dentin, and which, according to these writers, is a factor of some importance in the usefulness and preservation of the tooth.

Pathologic Tendencies of the Pulp.—It is owing to the marked pathologic tendencies of the pulp, especially after dentin formation has been completed, and to our inability, as a rule, to successfully cope with the morbid processes, that its removal is advocated by many as soon as it gives indications of being diseased. These pathologic tendencies are usually brought about through the action of pathogenic bacteria in a carious cavity, or through thermal or chemical irritation or compression acting upon the pulp in consequence of the loss of its protective covering. Hopewell-Smith has pointed out the great reparative power of the pulp which quickly manifests itself, when acted upon by an irritant, in a secondary formation (see chapter on Diseases of the Pulp). Under a mild degree of irritation the secondary formation (adventitious dentin) may extend over

a long period, acting as a protective covering to the pulp, until finally the pulp is reduced in size to a mere filament, and the canal may be almost obliterated. Under severe irritation this does not occur. If any secondary formation occurs, it usually assumes a different form. The response to the severer irritation results in a paralysis and dilatation of the blood vessels of the pulp, and, owing to the surrounding unyielding walls of dentin, the minute apical opening, the absence of lymphatics, as previously noted, passive hyperemia, inflammation, and degeneration quickly follow each other. Not only is great pain the concomitant of these various affections, but the final involvement of the pulp is *moist gangrene,* from which arises an apical abscess, and which in many instances leads to loss of the tooth.

Conditions which Indicate Pulp Conservation.—If the vitality of the pulp is threatened in the teeth of patients under twenty years of age, every effort should be put forth for the conservation of the pulp. In these instances root formation is not complete; the retention of the pulp, no matter what its condition may be, is likely to lead to completed formation of the end of the root, and, even though it may be necessary to remove the pulp at a later period, it is better to conservatively treat it and provide the probable opportunity for the completion of the root than to immediately remove it and incur the risk of the early loss of the tooth, which usually attends it when its root end is unformed.

If, in the preparation of a carious cavity for filling, an exposure is accidentally made, aseptic precautions having been maintained, no valid reasons exist why conservation should not be practiced, unless specially contraindicated. Hopewell-Smith has shown that under injury the pulp is fully capable of healing the injured area,

in the same manner as healing occurs in other parts of the body (see Diseases of the Pulp). It is not intended to recommend the conservative treatment in those instances of exposure occurring in the removal of the carious dentin, excepting as this may occur in very young patients, as previously noted. The risk of pulp infection is too great in those cases in which the overlying dentin is completely decalcified, and if conservation of the pulp is practiced, we are likely to find, sooner or later, the serious results following pulp infection.

If, for esthetic reasons, the maintenance of the *translucent appearance* [1] of the tooth is of paramount importance, or if it should be determined that, in the removal of the substance of the tooth necessary for pulp extirpation, a serious physical impairment of the crown is thereby established, likely to be followed by fracture, conservation of the pulp here may be considered allowable, providing no definite condition exists which clearly indicates its removal.

Conditions which Contraindicate Pulp Conservation.—If, in the removal of the decay from a carious cavity, the state of the overlying dentin expresses infection, experience has repeatedly demonstrated that the bacteria present in the dentin are likely to reach the pulp tissue, if they have not already done so, and that, even though persistent germicidal treatment might be indulged, this ordinarily fails to completely destroy the microörganic life present, and that eventually the pericementum becomes involved, through the septic proc-

[1] By the translucent appearance we do not indicate the color of the tooth. This, it has been maintained, is not dependent upon the vitality of the pulp, but upon the different colors of the dentin reflected through the enamel. But the translucent effect, *the lifelike effect*, is invariably destroyed when the pulp is removed even though the color of the tooth may not be altered.

esses of the pulp canal. In these instances it is better to remove the pulp prior to the placement of the permanent filling than incur the dangers of its conservation.

If the pulp gives evidence of a vascular disturbance exceeding an arterial hyperemia, no matter from what cause it may arise, the facts of its structure and anatomical surroundings strongly argue against conservation.

This may also be made to apply to conditions of abrasion and erosion, which require preparation, either for crowns, inlays, or fillings, as well as to those teeth that, owing to their form or position, require considerable removal of tooth structure in order to be properly prepared for the reception of a crown. In these cases the different irritants that may affect the dentinal fibrils, and through these the pulp, are so likely to set up serious vascular disturbances, which nearly always end in degeneration and necrosis of the pulp, that rather than incur these likely dangers with a probable pericemental involvement, or which, even if taken in time to guard against the involvement of the pericementum, may, nevertheless, offer at a later period great physical disadvantages to the removal of the pulp, and the effective filling of the pulp canal—in these cases it is better, in the beginning, to remove the pulp.

It is also maintained by a number of investigators that the removal of the pulp in advancing cases of pyorrhea is followed by very beneficial results. In the *Items of Interest,* 1901, page 195, Dr. J. L. Williams, of London, writes as follows: "There is another phase of this subject which should receive careful and thorough investigation. I refer to the possibility of very beneficial results growing out of the removal of the pulp in cases of loosening of the teeth from advancing destruction of the investing membrane from whatever cause or causes.

More than twenty years ago I pointed out the probability of an increased blood supply to the pericementum being one of the results of the removal of the pulp." Dr. M. L. Rhein reports very favorable results in certain forms of pyorrhea in which the pulp was removed to increase the pericemental supply of blood.

The fact, however, must not be overlooked that, whenever the pulp is removed from a tooth, the possibility of the formation of a blood clot at the apical end exists, and that this may be responsible for the apical irritation frequently noted after pulp removal, and, furthermore, unless this clot is thoroughly removed, it may at any time become the center of *septic processes* through the agency of bacteria, reaching the region by means of the circulation, or from the gum margin, and this may occur irrespective of the thoroughness applied in filling the root canal.

Treatment of Exposed Pulps.—The treatment of a pulp exposed in the preparation of the cavity requires considerable technical skill for its successful performance. This applies especially to the avoidance of *compression* of the pulp, either in placing the "capping" or in subsequently filling the cavity. Reference has been made (see Diseases of the Pulp) to the fact that of all forms of irritation that may affect the pulp it is most intolerant of compression. If undue pressure is made in applying the capping material, or unless precautions are taken which surely will guard against this development in the subsequent stages of filling the cavity, the plan of conserving the pulp will end in failure.

The tooth being under the dam, tepid water, sterilized, may be used to remove the blood from the cavity; this is followed by an application of alcohol. If pain is present it should be completely controlled before placing

the capping by the use of one of the non-irritating anodynes, such as cinnamon, cloves, camphophenique, or the combination of menthol, thymol, and phenol. For the capping itself one of several preparations may be selected; oxysulphate of zinc has given most excellent results in this relation. It consists of a powder and a fluid. The powder[1] is prepared by triturating in a mortar 1 part of effloresced sulphate of zinc, and adding 2½ parts of oxid of zinc; these are rubbed together, calcined at a glowing red heat for ten minutes, and when cool ground to a powder. This should be kept in a tightly stoppered bottle. The fluid is prepared by dissolving 10 grains of zinc chlorid in 1 drachm of water. When intended for use the powder and fluid are mixed together to a creamy consistency, and worked with the spatula until the mass gives indications of thickening; it is then placed over the exposure. Used in this manner oxysulphate of zinc is not surpassed in beneficial effects upon the pulp by any other known capping material. The concave metallic disk is generally used with the oxysulphate, or filled with a paste made of zinc oxid and one of the essential oils, and placed over the exposure, and is a safer plan of preventing undue pressure upon the pulp.

From time to time writers have urged objection to the use of zinc oxid because of the possible presence of arsenic, which is found in nature associated with zinc. This danger is more imaginary than real; however, those who seriously regard it may substitute for the zinc oxid precipitated calcium phosphate, as recommended by Dr. Buckley, and prepare a paste consisting of this and one of the essential oils, the paste being placed in the metallic disk and gently laid over the exposure.

[1] J. Foster Flagg.

The capper now being in position, several layers of cavitin, or rubber varnish, are applied to the dentinal walls, and the cavity filled with zinc phosphate. The varnish prevents the irritating impress of the phosphoric acid of the zinc phosphate, and its use cannot be too strongly emphasized. Many of the failures where conservation of the pulp is attempted are due to the neglect to protect the dentinal fibrils from the irritating impress of zinc phosphate, with which the cavity is filled as a temporary expedient until the success of the capping operation may be determined, and which are incorrectly attributed to other causes. The zinc phosphate filling may remain in place for six months, or a longer period, after which a permanent filling is introduced. In no instance is it a wise procedure to permanently fill the cavity immediately after capping the pulp. The attempted conservation of the pulp may end in failure, in which case it is usually necessary to remove the filling.

Plaster of paris mixed to a creamy consistency has been used as a protection to exposed pulp by many with considerable success. Several layers of bibulous paper, carrying chloro-percha or an antiseptic combination, and cut to a suitable form, have also been used, but has not been as successful as the aforementioned substances in protecting exposed pulps. As previously stated, the operation of filling a cavity in a tooth, the pulp being exposed and its conservation attempted, requires considerable technical skill. But, conjointly with this, a discriminating judgment must be exercised, after a careful consideration of all the related factors, which may in the very beginning decide for or against the operation.

CHAPTER XVII

THE REMOVAL OF THE DENTAL PULP

A careful consideration of the related factors at times clearly indicates that the removal of the pulp will subserve the best interests of the tooth. This may be performed under the following methods:

1. By means of arsenic.
2. By means of different local anesthetic solutions made to enter into the tissues of the pulp by pressure or otherwise.
3. By means of nitrous oxid.

1. By Means of Arsenic.—Dr. Spooner introduced the use of arsenic for pulp devitalization in 1836. It has been in continuous use for this purpose ever since, and gives promise of maintaining its preëminently useful position for some years to follow. The few (considering the frequency of its use) instances in which the application has been followed by necrosis, owing to ignorance and carelessness, are valueless in condemning this agent for its intended dental purpose. In fully formed teeth, when properly applied and sealed, it safely and positively, excepting in very rare instances, devitalizes the pulp, allowing of its complete extirpation without pain, and, in the opinion of the writers, is less likely to be followed by subsequent complications than in the removal of the pulp by any other method.

Action of Arsenic upon the Pulp.—The investigations of Arkövy[1] disclose the following action:

"1.—As_2O_3 brought into contact with the tooth pulp acts in the following way: A certain degree of inflammatory hyperemia, total or partial, depending upon the quantity of the agent applied, sets in; the blood vessels become expanded, and here have a tendency to thrombosis. This latter effect may also be in connection with embolism of the capillaries, when the agent is quickly taken up into the blood vessels.

"2.—As_2O_3 produces no coagulation of tissue whatever.

"3.—It has a specific influence upon the blood corpuscles, combining with the hemoglobin to form a compound of arsen-hemoglobin, and of this chemical process there seems to be evidence in the profuse yellowish tinge of the whole pulp tissue and in the discoloration of blood in several of the blood vessels.

"4.—In nearly every case it is taken up *in substantia* (in form of molecules) into the blood-ways, granular detritus of the contents, and anemic collapse-shrinkage, the latter effect being brought about nearly exclusively in cases where greater doses were used.

"5.—The bulk of the pulp tissue—viz., connective tissue fibers and odontoblasts—undergoes no change whatever; not so the connective-tissue cells, which increase to three or four times their normal size.

"6.—The special action of arsenic trioxid upon the nerve elements consists in the following: The neurilemma is only so far influenced that its nuclei are somewhat increased; a more essential change takes place in the axial part, where, after the application of more than one mgrm., granular destruction of myelin sets in, and

[1] Burchard's "Pathology."

the axis-cylinder commences here and there to disappear. A very surprising alteration may be seen in the notchy tumefaction of the axis-cylinder, described heretofore almost only in cases of central lesions.

"7.—All these alterations occur in and among normal-looking tissue.

"8.—The action of arsenic trioxid is macroscopically exhibited by a brownish-red tinging of the whole or of certain parts of the pulp body, as well as of the neighboring dentin and cementum, this latter in cases treated with greater doses—viz., two to five mgrms. This alteration is most expressed at the top of the crown pulp and at the apical one-fourth to one-third part. This circumstance may be considered as an external evidence of the devitalization being completely attained to."

The experiments of Miller [1] are corroborative of the above conclusions.

It has been argued that an application of arsenic to the pulp may escape through the apical opening, even in fully formed teeth, and affect the apical pericementum. In an experience of over thirty years the writers have been unable to observe any ill effects from its use, and, while occasionally an apical irritation will manifest itself, this promptly disappears, after resort to therapeutic measures. No positive evidence has ever been presented, to the writers' knowledge, that the apical irritation is due to the escape of arsenic through the opening at the end of the root. That disastrous results have followed arsenical applications is not denied, but in all instances these could be traced, either to an improperly sealed application allowing leakage at the gum margin, or its escape through a perforation, or through an unformed or resorbed root end. The pericemental

[1] *Dental Cosmos*, 1894.

irritation is due to the increased amount of blood flowing into the pulp, due to the highly irritative effect of arsenic, and its extension to the pericementum, resulting in a mild or severe hyperemia of the membrane. Miller's experiments show that, with the marked stasis existing at the apical portion of the pulp, an impassable barrier here exists to the passage of arsenic; therefore its necrotic effect is exerted upon the pulp alone, excepting in those instances, previously noted, where it may escape through an enlarged root end, or through a perforation in the side of the root, or through a leaky filling at the gum margin.

Most pulps succumb to the application of arsenic after 48 hours. In most cases this occurs with little pain; in a few a severe reaction follows, necessitating the removal of the arsenic and the use of anodynes persistently applied until the pain is controlled. In these cases it is better to defer a second application of arsenic for twenty-four hours. If this is again followed by an acute paroxysmal attack, which shows no disposition to lessen—in fact, rather gains in intensity—the presence of pulp nodules, or some other form of calcific degeneration, may be inferred. It may then be necessary to puncture a minute quantity of the paste into the pulp, and in very obstinate cases the use of nitrous oxid may be necessary.

Frequently the application is followed, in about one hour, by a sense of fullness within the tooth, and of slight throbbing; this may persist for several hours and gradually disappear; when the patient returns after 48 hours the pulp is found to be completely devitalized. It is not wise to attempt its extirpation at this time, mainly because sufficient time has not passed for a natural separation to occur at the apical end; and, if attempted,

a laceration of tissue is likely to occur, which not only may be followed by irritation, but a blood clot may form in this region, *which is a menace to the tooth as long as it remains at the end of the root.* The writers prefer sealing an antiseptic in the cavity, and dismissing the patient for *one week,* when extirpation will be found to be more easily accomplished, and the complete thrombosis existing in the apical region prevents oozing of the blood and the formation of a clot about the apex.

If pressure is exerted upon the pulp in sealing the application, pain promptly follows, in which state the arsenic simply augments the irritation, but is not absorbed; therefore, in closing the cavity it is imperatively necessary to avoid pressure upon the pulp, otherwise the application ends in failure. To successfully guard against pressure in applying arsenic, the filling material is first applied to the parietes in such a manner as to leave a central opening leading to the exposure; through this opening the arsenical paste is applied, and the external opening closed, in much the same way as the lid is placed upon a box. This method of sealing the application positively safeguards against compression of the pulp, and, as this is a very important factor in the success of the action of the devitalizing paste, it cannot be unduly emphasized.

The materials generally employed for sealing an arsenical application are temporary stopping and zinc phosphate. These materials guard against leakage of the arsenic, and may be conveniently utilized for sealing the application. This does not apply to *gutta percha, therefore it should not be used for the purpose of sealing an arsenical application.* Many of the accidents following the use of arsenic occurred when this agent was sealed in the cavity under gutta percha. Apparently

it allows of the escape of arsenic and the destruction of the gum tissue, alveolar walls, pericementum, and bone follows. The gum, when acted upon by arsenic, quickly changes to a deep purplish color, and later to a muddy slough. These effects may be noted upon the gum festoon of one or more teeth, or it may destroy the pericementum, causing loss of the tooth. In these cases the alveolar wall is also affected, and finally sequestrates.

The worst case of arsenical necrosis seen by the writers followed the use of "toothache drops" upon the

FIG. 96.—BOENNING'S CASE OF COAGULATION NECROSIS DUE TO ARSENIC. (Burchard and Inglis:—"Pathol.")

gum (this case is reported in Burchard's and Inglis' "Pathology") (Fig. 96). "The teeth from the right lower cuspid to the left lower second temporary molar, and the gums over the process, were lost, leaving a blackened alveolar process to be later removed surgically."

As soon as the gum tissue gives indication of the escape of arsenic, the application should be immediately removed from the cavity, the cavity and surrounding tissue thoroughly sprayed, and all affected gum cut away until free bleeding is induced. The application of iron

he affected area, as recommended by some writers,[1] is well founded. It is a good plan to inform all patients he possible effects of arsenic, if anything is done to w its escape, and therefore care should be exercised to disturb the integrity of the filling, or to attempt removal under a severe paroxysm of pain. Under e instructions to the patient, and with the methods, iere discussed, the writers have been entirely free n all accidents, and singularly successful in the de- lization of pulps with arsenic, in a practice of over nty years.

Numerous formulæ have been introduced for arseni- pastes. The writers prefer making the paste as re- 'ed at each application, by adding a minute quantity ne of the essential oils to a combination of one part nious acid and two parts cocain hydrochlorate; suffi- t of this combination is taken upon the spatula to esent about 1/25 grain of arsenic, and moistened oil of cloves or cinnamon; this is gathered upon a ead pledget of cotton and carried to the exposure, if exists, or to the pulp region, if no exposure exists. ntractable pulps occasionally present which are non- onsive to the devitalizing action of arsenic. Whether stubborn resistance is an expression of idiosyncrasy f a pathological condition of the pulp has not been rmined. Such pulps cannot be devitalized by means 'senic; when this agent is used severe pain develops, its action upon the pulp does not pass the irritative e. Such pulps must be removed by some other od.

Means of Local Anesthetics Made to Enter the Tissue by Pressure or Otherwise.—The advent taphoresis in dentistry for a time appeared to mark

[1] Burchard and Inglis, "Pathology."

a definite period in its progressive evolution. All sorts of extravagant predictions were made for it, and many advised the complete elimination from dental practice of the usual remedies for hypersensitive dentin, and of arsenic for the devitalization of the pulp, as by the use of cataphoresis exquisitely sensitive tooth structure and the pulp could be completely anesthetized, to enable the operator to prepare cavities and to extirpate the pulp, if this were necessary, without the slightest infliction.

In many instances the efficiency of cataphoresis was effectively illustrated. In others it was a complete failure. But in all cases in which the method was employed an expensive apparatus was necessary, and much time was consumed in its operation, with the final result in doubt. With the introduction of the so-called *pressure anesthesia,* which soon demonstrated a greater degree of effective application, and which required, apart from the anesthetic agent, only a simple hand instrument, and consumed but several minutes for its operation, the former method quickly passed into a state of "innocuous desuetude." At the present time cataphoresis exists but as a reminder of a glorious promise, and, while in some cases it may be effectively employed for the obtunding of hypersensitive dentin, also for the extirpation of the pulp, the final results obtained are too uncertain, and the time consumed in its operation exceeds that at the command of the busy practitioner.

Pressure Anesthesia.—This method consists of forcing solutions of cocain hydrochlorid, or other local anesthetics, into the pulp by means of pressure, anesthetizing the organ, enabling the operator to painlessly remove it. In utilizing this method, it is important to bear in mind that, unless thorough *aseptic precautions* are taken, infective material may reach the apical region

and subsequently involve the pericementum in a septic process. It is also important to bear in mind that, if carious dentin covers the pulp, its *sterilization* is necessary before the anesthetization of the pulp is attempted, otherwise bacteria and poisonous ptomains may be forced into the apical region and initiate pathological complications, terminating in loss of the tooth. Miller's experiments conclusively show that the ordinary methods in vogue are almost valueless in rendering carious dentin sterile. The sterilizing agent should remain in contact with the infected dentin for a considerable time, depending upon the intensity of action and penetrating power of the agent, or agents, used to accomplish the purpose of sterilization; also the amount of dentin covering the pulp. Twenty-four to forty-eight hours may be required. If but a thin layer of dentin overlies the pulp less time is necessary; here a saturated solution of thymol, to which formalin added to make a one or two per cent. solution is very effective in its action, at the end of ten to twenty minutes. Stronger solutions of formalin may be used, but pulp irritation is likely to follow. Dr. Buckley [1] claims unusual effectiveness for a 25 per cent. solution of sulphuric acid.

The dentin having been sterilized, the cavity may now be flooded with alcohol and dried with blasts of warm air, after which it is ready for the anesthetic solution. This usually consists of a solution of cocain hydrochlorid in varying strength. Some prefer the use of a mild solution, about 2 per cent.; others prefer stronger solutions, up to 12 and 15 per cent. The mild solutions appear to be as effective as the strongest. A small pledget of cotton saturated with the solution is placed as near to the pulp as possible; a piece of vulcanizable

[1] Johnson's "Operative Dentistry."

rubber of suitable size is cut, and passed through the flame of an alcohol lamp for sterilization, and placed over the cotton. Pressure with an instrument, the end of which nearly fills the cavity, is made upon the rubber and, at the end of about two minutes, in most cases, the pulp can be exposed. After its exposure one application is usually sufficient to completely anesthetize it. Although this method of pulp anesthetization is ineffective in a few instances, the proportion of successful cases is greater than with the cataphoric method, and, as the pressure method affords a great saving of time, it has almost entirely superseded the method of forcing anesthetic solutions into the pulp by means of the cataphoric apparatus.

Several instruments have been devised for the purpose of forcing cocain or other anesthetic solutions into the pulp tissue. These resemble in principle the hypodermic syringe, and, while they subserve a useful purpose in effectively forcing anesthetic solutions into the pulp, it is only in very rare instances that the pulp cannot be removed by the simpler method, previously described, of forcing the solution into its substance. An objection urged against the use of the pressure syringe is the likelihood of forcing the solution into the apical pericementum and setting up a pericemental irritation.

A word of caution here may be in place. In the chapter of The Treatment of Hypersensitive Dentin reference was made to the poisonous effect of cocain upon the pulp, and to the fact that in many instances of its use for obtunding the dentin, especially when used under pressure and carried into the pulp, death of this organ followed at a later period. This prohibits its use under pressure for obtunding the dentin, unless great care is exercised not to force the drug into the pulp, or unless

pulp removal is intended. Observations [1] are also recorded that, if this agent is forced beyond the apex of the root, pericementitis is a likely result, following its poisonous effect upon the apical pericementum. Various drugs from time to time have been suggested in place of cocain. Among these *nervocidin* has been strongly endorsed in some quarters, but it is not likely that it or any other drug of which we have knowledge at the present time will entirely take the place of cocain for the production of local anesthesia.

By Means of Nitrous Oxid.—In rare instances it may be necessary to anesthetize the patient, to be able to remove the pulp. For this purpose nitrous oxid is admirably suited, and perhaps better adapted than the other anesthetic agents. While the anesthesia resulting from its administration is of short duration, this usually suffices for the removal of the pulp in the single-rooted teeth, if adequate preliminary preparations have been made. In molars its use may be of service in removing the filament from one canal, although when administered combined with oxygen the anesthetic state may be maintained from two to five minutes, and even for a longer period, under which considerable work can be performed. The *safety* of this agent has an important bearing in favor of its use, and, while the method of rendering the patient unconscious for the operation of pulp removal is only resorted to after all other means commonly employed fail, it would be inadmissible if attended with dangerous risks; but, as the record of considerably over a half century justifies the claim made for it as being the *safest anesthetic,* and almost entirely free from danger, its use may be indulged with confidence in those instances, previously noted, in which the

[1] Johnson's "Operative Dentistry," page 321.

pulp, perhaps idiosyncratically, cannot be affected by arsenic, nor does it respond to cocain and pressure.

Anesthetizing the pulp by means of cocain, or anesthetizing the patient by means of nitrous oxid, either method demands immediate pulp removal. In the writers' estimation the removal of the pulp under any method which is likely to be followed by the formation of a blood clot in the apical region, as previously noted, is a procedure fraught with dangerous probabilities for the permanent retention of the tooth. It is for this reason that the devitalization of the pulp by means of arsenic is favored, and that its extirpation is delayed for about one week after devitalization, so that the complete thrombosis of the apical vessels will prevent the hemorrhage that is so likely to follow when this condition is not realized at the apex, and thus eliminate a probable factor of pathological involvement of the root of the tooth.

The Removal of the Pulp.—Direct communication with each canal must be established, in a manner that will not only allow of the removal of the pulp, but will also favor the thorough filling of the canals after the pulp has been removed. This approach to each canal must be secured irrespective of the loss of tooth substance. This does not signify needless removal of tooth structure, which at all times should be guarded against, but emphatically declares for such lines of approach as may conduce to the thorough filling of each canal. The loss of tooth structure should be subordinated, at all times, to the healthy state of the canals, upon which the permanent retention of the tooth, in a large degree, depends. Having secured the proper lines of approach, a sterilized broach is introduced between the pulp and dentinal wall and forced as close to the apex as may be

possible; the broach is then rotated between the fingers and withdrawn. The pulp *en masse* usually will be found wound upon the broach.

Attenuated canals generally require enlargement in order to free them of their organic contents. This can be accomplished with the Kerr or Downie reamers, using successive sizes until the apex is reached, or the plan of treatment introduced by Dr. Callahan will be found of great service. This method consists of pumping 50 per cent. sulphuric acid into the canal by means of a Donaldson cleanser until the apex is reached. Dr. Callahan's method marks a distinct advance in canal work and cannot be too highly extolled. Through it the finest canal can be successfully opened to the apex. (See chapter on Root Canal Filling.) When the acid combines with the calcium salts of the dentin, it also destroys the pulp filament which, in many cases, cannot be removed in any other manner; it reaches into the dental tubuli, and partly destroys their organic contents. It carbonizes the organic matter in the canal, and this is acted upon by potassium sodium and completely destroyed.

Thorough aseptic precautions must be maintained throughout the entire operation. A feature of great value in the use of sulphuric acid in canals is the removal of the detritus from the canal, by the liberation of carbonic acid gas when the acid is neutralized with a solution of sodium bicarbonate. After the neutralization of the acid, the cavity and canals are dried by means of alcohol and blasts of warmed air, and a fine broach is introduced to determine if the apex can be reached; if not, the sulphuric acid treatment is repeated, until the patient, generally by a movement of the head, indicates a tenderness, which is usually a symptom that the apex has been reached.

CHAPTER XVIII

ROOT CANAL FILLING

The removal of the organic contents of canals, by mechanical means in the larger canals, and with the assistance of chemical agents in the smaller canals, as discussed in the preceding chapter, must be as thoroughly performed as conditions will allow, in order that the canal may be thoroughly filled to the exclusion of those pathogenic factors which, if present in the canal, are so likely to lead to serious disturbances. The removal of all organic matter from the root of the tooth can never be perfectly realized. The pulp can be completely removed in many cases, but in no instance can the organic contents of the tubes be removed, or so acted upon by chemical agents introduced into the canal that we can rest secure in the knowledge of the *impossibility* of future septic involvement of the root end. For this reason asepsis must be effectively maintained during the operation of filling the canal; and for this reason the canal should be thoroughly filled, in the hope that thereby septic organisms may be excluded, which alone are capable of effecting those changes against which the most painstaking efforts at times are unavailing.

Effective asepsis can, as a rule, be realized in the use of the dam and germicidal agents; not so the perfect filling of the canal. This is realized in but comparatively few instances. In the anterior teeth, especially the su-

perior, with their rounded canals, after the removal of the pulp, the perfect filling of the canal is not an impossibility. With the buccal canals of the superior molars, and the anterior canals of the inferior molars, even though chemical agents may have aided in the enlargement of the canal, and in the removal of its organic contents, the perfect filling of the canal is rarely attained, irrespective of the material used. The perfect filling of the canal implies the complete occupancy of the canal from which the pulp has been removed. Not the slightest space may exist below the apical foramen, nor may the material extend beyond it. In the rounded canals of the superior anterior teeth it may not be impossible to attain this ideal condition; but in the treatment of the posterior teeth it may be regarded as an impossibility, so rarely is the perfect filling of these canals accomplished, as may be seen from X-ray pictures of filled canals, also from the variety of methods and materials from time to time suggested, in the hope of attaining a perfect method. As previously stated, a perfect result can be secured in very few cases of canal treatment.

Many writers agree that, of all the materials available for filling root canals, the combination of chloropercha followed by gutta percha points, or the introduction into the canal of *eucalyptol* pumped well to the apex, and followed by cones of heated gutta percha, yields the best results. If this conclusion is correct, and, from the large number declaring in its favor, it appears to be, then the perfect filling of the canal is not essential for good results. Gutta percha placed in the canal does not perfectly seal the canal, and, if the general consensus in its favor is well founded, the former conclusion is unavoidable.

The many examples of canals imperfectly filled that have persisted for years without pathological complications, to which fact many practitioners can testify, offers corroborative evidence that the essential requisite of success in canal treatment does not exist in the perfect closure of the canal. Heretofore all efforts have been directed to the thorough removal of the organic contents of the canal, followed by its thorough filling, as the best means of avoiding subsequent septic complications. That these are necessary steps in canal work requires no reaffirmation. They are self-evident in view of modern pathological knowledge; but that success can only be attained in those cases in which these requirements are absolutely met, or that subsequent septic complications are impossible when the above demands have been fulfilled, cannot be allowed.

In the preceding chapter, in discussing the various methods of pulp removal, emphasis was placed upon the desirability of adopting that method whereby the formation of a blood clot in the apical area might be avoided, otherwise apical irritation is quite likely to follow, and, what is still more important, there is the likelihood of septic organisms inaugurating a septic process in this clot, and this might take place irrespective of the thoroughness with which all organic matter had been removed from the canal, or with which the canal had been subsequently filled. The importance of the blood clot in the apical area as a causative factor in the future septic involvement of the root, by affording a suitable habitat for septic organisms, has not heretofore been sufficiently emphasized. The organic remnant of the canal and tubes has been regarded as the chief agent of future pathological development by providing the conditions necessary for bacterial activity, and for this rea-

son all efforts have been directed to effect the complete removal of all organic matter from the pulp canal, and then to fill it in a manner that would exclude micro-organisms. These are very important steps in canal treatment, and, in proportion as they may be fully realized, so is the likelihood of future septic involvement originating from this source reduced. But, if the pulp has been removed in a manner most probably followed by a hemorrhage in the apical area, and the formation of a blood clot, a very favorable field for bacterial activity thereby has been created in a directly accessible region, for the elimination of which, in an inaccessible region, the most painstaking efforts may have been practiced. Therefore, in canal treatment, it is equally, if not more, important to avoid the formation of a blood clot in the apical area, as to avoid leaving organic matter in the canal. Either supplies a fertile field for bacterial activity. The organic matter in the canal may be acted upon by chemicals, as is claimed by many, to render it unsuited for bacterial development. It is quite impossible to similarly affect a blood clot in the apical region.

In the writers' experience, as has been stated in the chapter, "Removal of the Dental Pulp," the surest method of avoiding the formation of a clot in the periapical region is to devitalize the pulp by means of arsenic, and allow about one week after its devitalization before proceeding with its removal. The strangulation at the apex following the action of arsenic is followed by thrombosis, and, after the lapse of the specified time, the natural separation occurring between the vital and devitalized tissues facilitates pulp removal, and the apical region, in view of the changes occurring in the blood vessels and adjacent cells, is most likely free of blood; hence, no clot can form. This eliminates one probable

source of subsequent pathological involvement to which too little attention is paid in the operation of pulp removal and the filling of the root canal.

If, then, the pulp, let us say, of one of the superior anterior teeth is removed in the manner previously suggested, and the canal filled under strict aseptic precautions, it is not likely that we will find subsequent pathological disturbances, no matter which one of the many materials suggested as appropriate canal fillings may have been utilized. It is our firm belief that, if no septic organisms are carried into the canal in the act of pulp removal, or filling the canal, it is not likely that any will enter the canal by way of the apical foramen; and the fact that canals filled with cotton have maintained their integrity for thirty years and more, as stated by Dr. Peirce before the New Jersey State Dental Association, and also by others, sustains this conclusion. Septic organisms may reach the apical region by way of the circulation, or a pyorrhea pocket, and, if this region does not afford the suitable requirements for their activity and propagation, no complications will ensue. However, if a remnant of the pulp has been allowed to remain, or if, in the act of pulp removal, the hemorrhage from the torn vessels has resulted in the formation of blood clots about the apex, the suitable conditions for bacterial activity exist, and complications usually follow.

In filling the tortuous and attenuated canals of bicuspids and molars, no plan of treatment before the profession equals the value of the so-called "*Callahan method.*" Dr. Callahan[1] describes his method as follows: "With a Gates-Glidden drill, as large as conditions will permit, we start the funnel shape at the mouth of the canal (C) (Fig. 97), being careful to have the

[1] Transactions of the National Dental Ass., 1909.

canal as dry as possible, for it is in the wet canals that the drills lock and break. Be careful to allow the drill to go only far enough to make a pocket, say, of a depth equal to half the length of the head of the drill.

Fig. 97.—(After Dr. Callahan.)

"A smaller Gates-Glidden drill will then go a little farther into the canal (D), the operator being careful to stop short of a curve. Then place a drop of forty per cent. sulphuric acid in the pocket; next, with the largest Donaldson broach that will enter the canal at the extremity of the pocket thus made (E), begin pumping, enlarging the canal to the size of that broach as far as possible. Then repeat the process, using this time a smaller broach (F), keeping fresh acid in the canal and continuing the gentle manipulation of the broach until an obstruction is met with.

"Then, with cotton or a small syringe, introduce into the cavity a saturated solution of sodium bicarbonate, and note what happens. If there be sufficient acid in the canal, enough carbonic acid gas is manufactured to cause a series of rapid and easily noticed explosions, coming from the very end of the canal, carrying every particle of débris out of it, leaving it cleaner than it can be made by any other practical procedure.

"The obstruction met with consists either of cementum at the apex of the root or of pulp tissue rammed ahead of the broach. At this point it may be pertinent to inquire as to what has happened to the minute fragment of pulp tissue in the remaining twentieth of an inch of the canal at the apex. It is reasonable to suppose that the acid, by the time it reaches this point, is

neutralized, a little at least, and the pulp fragments have been changed somewhat, carbonized slightly and somewhat hardened, but are still freely soluble in the presence of sodium potassium.

"The enlarging, straightening, and smoothing of the canal, as above described, enable us to carry on a worn No. 5 Donaldson broach small particles of sodium potassium to these pulp fragments, with a reasonable certainty that they will be dissolved or broken up by the strong alkali. Then the soapy residue should be gotten rid of, lest if left in the apex or apical space it would in time be so changed that it would become attractive to germ life. Such is the uncertainty of getting water to it with sufficient force, that I have made a second application of sulphuric acid, followed by a sodium bicarbonate solution, with the idea that the liberation of the resultant carbonic acid gas would free the canal of every deleterious substance."

After the canal has been treated in this manner, the apical end may be filled with chloro-percha and a gutta percha point, and the remaining portion with oxychlorid of zinc. This is the method of filling adopted by Dr. Callahan. Others fill the canal with chloro-percha and gutta percha points. Paraffin, wax, used alone or in combination with an antiseptic, also the various antiseptic pastes, which closely resemble the mummifying combinations, each may claim many supporters, and with each permanent results may be attained, providing the conditions are favorable. In other words if effective asepsis has been maintained during the operation of pulp removal, and if the apical region immediately within and beyond the apex is devoid of clotted blood and shreds of pulp tissue, it is extremely improbable that septic complications will follow the use of any of the materials

ordinarily utilized for filling the pulp canal. This is a rational conclusion sustained by the notable records at times made by such different materials, used as canal fillings, as cotton, gold, oxychlorid of zinc, gutta percha, wax, and the various antiseptic pastes, and in other instances the early pathological disturbances in the apical region following the use of these various materials, most probably due to unfavorable conditions within or about the apical region, and not to the filling material.

Pulp Mummification.—The frequent failures following the use of the various materials used in filling the root canal, and by many attributed as being due almost always to the inability to fill perfectly but a small percentage of the root canals that are presented for treatment, has led to the practice of allowing the root portion of the pulp to remain *in situ* and then placing certain chemical agents in contact with the organic remnant in the canal, with the object of so altering its chemical aspect as to make it unfit for bacterial activity, and in this manner avoid the pathological sequelæ that usually follow the inauguration of a septic process within the canal or about the apex. The practice of allowing the root portion of the pulp to remain in the canal and covering this with a strong antiseptic paste originated with Dr. Adolph Witzel[1] in 1872. The paste, which consisted of bichlorid of mercury and other ingredients, according to Dr. Witzel, caused the pulp remnant in the root to shrink and remain as dry antiseptic bodies, "a far better filling for the roots than the purest gold." The discoloration of the tooth which followed the use of this paste, and which usually follows the use of any preparation containing mercury, induced Dr. Soderberg, of Sydney, Australia, to experiment with different pastes to

[1] *Dental Cosmos,* 1893, p. 364.

find one which would change the character of the organic contents of the canal, i. e., *mummify it,* without the objectionable effect of discoloration of the crown, noted in the use of the paste recommended by Witzel.

Dr. Soderberg[1] describes the properties of an ideal mummification paste as follows:

"1. It must contain an antiseptic sufficiently strong to prevent decomposition taking place while mummification sets in. Once mummified the pulp is (so at least I believe) not very likely to become decomposed and putrid.

"2. It must contain an ingredient which will, as quickly as possible, cause mummification (drying, shriveling) of the pulp tissues.

"3. It must contain a substance which, in conjunction with the other ingredients, will impart a white color to the mummified pulp, and prevent discoloration of the tooth.

"4. It must contain an agent capable of binding the whole compound together in a pasty state, and making it penetrate deeply and quickly."

Dr. Soderberg finally recommended the following combination as a suitable paste:

℞	Dried alum	ʒj
	Thymol	ʒj
	Glycerol	ʒj
	Zinc oxid, q. s., to make stiff paste.	

In the *Cosmos*, 1900, Dr. Soderberg reports as follows: "Since 1894, out of a total number of about nine hundred cases of pulp amputation treated by me with the mummification paste, as published in the *Dental Cos-*

[1] *Dental Cosmos*, November, 1895.

CHAPTER XIX

THE EXCLUSION OF MOISTURE DURING OPERATIONS

The aseptic requirements of certain operations about the teeth make it imperatively necessary to exclude the germ-laden saliva from the field of operation. This applies especially to the treatment of root canals, and to the filling of cavities of decay.

If septic organisms are carried into the root canal or cavity of decay by means of the saliva, no matter with what degree of thoroughness the various other steps of either operation may be performed, failure is likely to ensue.

The exclusion of moisture is also a necessary condition in the use of cohesive foil. Unless dryness is perfectly maintained, the cohesiveness between the particles of gold is destroyed, and the operative procedure must be discontinued. In the treatment of hypersensitive dentin, unless dryness is secured, the obtunding effect is lost of almost all the therapeutic agents usually applied in the treatment of this condition. In fact, the maintenance of dryness itself constitutes a form of therapeusis, and it will almost invariably be found in the preparation of cavities that, if moisture is excluded, the response to the cutting instruments is materially lessened.

Our knowledge of the pathology of caries is sufficiently advanced to indicate clearly the necessity for maintaining dryness during cavity preparation, not only to

prescribes the thorough removal of the organic contents of the canal, i. e., as thorough as may be possible, followed by the use of the paste so enthusiastically advocated by an increasing number of operators, and by means of which almost unvarying success is reported when placed in contact with the root portion of the pulp, which had been previously devitalized and intentionally allowed to remain in place to be acted upon and mummified by the combination of chemical agents introduced for this purpose by Dr. Soderberg. The less organic matter that is allowed to remain in the canal, the greater the quantity of the paste that can be introduced; hence the putrefiable mass is materially reduced, while the antiseptic value of the filling is increased.

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prevent ingress with the saliva of septic organisms, but in order to secure the best possible view of the cavity and its margins. The presence of moisture, by refracting the rays of light, disturbs the proper view of the different parts of the cavity, and renders invisible marginal imperfections, which are likely to remain and cause early recurrence of caries.

The Rubber Dam.—The introduction of the rubber dam by Dr. Sanford C. Barnum, in 1864, made possible filling operations with gold, previously viewed as impossible, and always will be associated with the new era in operative procedures with gold. In many instances dryness can be maintained by the use of napkins and cotton rolls, and the fact that, previous to the introduction of the dam, gold fillings were introduced that perfectly conserved the teeth in which they were placed for fifteen and twenty years, and, in many instances, for a greater period, attests to the correctness of the above statement; also to the manipulative excellence acquired by many of the older practitioners.

In proximal and gingival cavities, extending to and below the gingival border, it is essential to adjust the dam. While it cannot be denied that, prior to the introduction of rubber, excellent filling operations were made in similar locations, at the present time it does not appear prudent to incur the risk of failure owing to the escape of moisture from the gum tissue. Considerable difficulty at times may be encountered in securely adjusting the dam in these cases, but with experience the technical difficulties are usually mastered, and the sense of security thereby gained, as well as the free use of both hands, easily compensates for the efforts expended in mastering the attending difficulties.

In occlusal cavities the adjustment of the dam, as a rule, is very readily accomplished, and, although it is not difficult in these cases to maintain dryness without its aid, nevertheless the operation is considerably simplified, in the absolute sense of security from escaping moisture gained by its use, which can never be as complete when moisture is excluded by other means.

Rubber dam is supplied in three thicknesses: heavy, medium, and light. The medium grade is generally employed, as it meets the ordinary requirements better than either of the other grades. The thinner the dam the easier it is torn during the adjustment process, as well as subsequently, if the bur or any other sharp instrument should be forced against it. The heavy grade dam, on the other hand, is very difficult to adjust if the teeth are in close contact. Therefore, the medium grade, as previously indicated, better meets the general requirements, if but one grade is employed.

The form to which the dam is cut when intended for use over teeth is usually that of a *triangle.* This is best suited and most economical for almost all cases. For the anterior teeth the piece may be cut from a width of about six inches; for the posterior teeth the width is larger; rarely, if ever, however, exceeding nine inches, and in most cases seven and one-half inches will be found ample.

The dam is now ready to be perforated for the passage of the teeth. The perforations are usually made with the rubber dam punch, which is provided with a steel disk having different sized holes, enabling the operator to make the perforations in the dam according to the requirements of the case. The distances between the perforations should be so arranged that when the dam is adjusted it should not fold in the interproximal space;

neither should it expose the gum tissue. Either arrangement is faulty and likely to end unsuccessfully. Dr. Jack [1] advises the following plans for the different locations: Fig. 98 illustrates the triangular form of the dam; the dots show the perforations through which

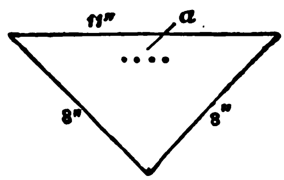

FIG. 98.—SUPERIOR INCISORS.

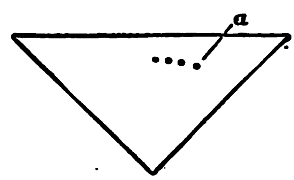

FIG. 99.—SUPERIOR BICUSPIDS AND MOLARS.

the teeth pass. This is for the *superior central incisors.* Fig. 99 illustrates the arrangement for the *superior bicuspids and molars.* The perforations are not parallel with the edge of the dam. Fig. 100 illustrates the arrangement for the *inferior bicuspids and molars,* and

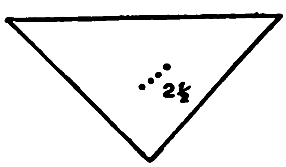

FIG. 100.—INFERIOR BICUSPIDS AND MOLARS.

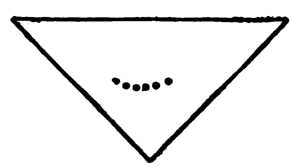

FIG. 101.—INFERIOR ANTERIOR TEETH. (Dr. Jack.)

Fig. 101 shows the arrangement for the *inferior anterior teeth.*

Frequently the error is made of including fewer teeth in the isolation by the dam than is required for convenience in the operative procedure. Not only does this interfere with the convenience under which the filling may be introduced, but the operation may terminate disastrously at almost any stage by the tearing of the dam with a sharp instrument, or the presence of mois-

[1] "American Textbook of Operative Dentistry."

ture owing to the slipping of the dam from position. It is always a good plan to include two teeth on either side of the one to be filled in the anterior portion of the mouth. For posterior teeth the one distal to the one to be filled, as well as several anterior to it, should be included in the isolation.

ADJUSTING THE DAM.—It is well, before adjusting the dam, to note the character of the joint formed between the tooth and the alveolar walls. In some instances the teeth are so rigidly held in their sockets that a preliminary separation may be necessary before placement of the rubber can be effected. This extreme fixation of the teeth is nearly always associated with abrasion and an "end to end bite," resulting in sharp edges of enamel, all of which interfere with the placement of the dam. In these instances at times the forcible insertion of a thin-bladed instrument, or floss carrying vaselin, may prove to be adequate for the requirements; if not, the preliminary separation previously suggested must be followed. All teeth upon which the dam is to be placed should have all deposits and adhering detritus removed, and the surfaces thoroughly wiped with alcohol, before the dam is placed in position. Failure to comply with this precautionary measure is fraught, in many cases, with serious consequences to the future normal aspects of the tooth.

When these preliminary steps have been carried out the dam is ready for placement. As a rule, it is carried first over the anterior tooth, and then over each adjoining tooth, until all to be isolated are included. This is accomplished by stretching the dam and forcing the edge downward between the teeth until it passes the contact point. If the teeth have not been separated and the contact form still exists, the rubber is likely to remain

in position, unless the conical form of the crown and an excessive muscular action of the lip induce it to slip past the contact point and come off. This frequently occurs in adjusting the dam upon the cuspids. In stubborn situations considerable time may be conserved by first adjusting the dam upon the first bicuspid and carrying it over the successive teeth, leaving the cuspid for the final effort. At this stage, the dam being secured upon the first bicuspid, the rubber is forced into the interstice between the cuspid and lateral, and by means of a drawing movement given the ligature the dam is carried to the gum border, its edge inverted, and the ligature tied in position. When the superior third molar is to be isolated, owing to its somewhat conical form, it is advisable to retain the dam in position by means of a clamp. In these cases the clamp is slipped through the posterior perforation in the dam and adjusted to the tooth; the dam is next adapted to the gum border by means of the ligature. The adjustment of the dam is then made upon the adjoining tooth and proceeded with until the necessary teeth are included.

In many instances where the dam is utilized for the exclusion of moisture it is not necessary to secure it in position by means of either ligature or clamp. This occurs frequently in incisal and occlusal operations. In proximal cavities in incisors and cuspids the dam should always be secured by means of the ligature. A limited experience is sufficient to emphasize the necessity of this precaution. Not only should the tooth with the cavity be ligated, but the adjoining ones as well; otherwise the entrance of moisture is likely at any time to interfere with the continuance of the operation. In bicuspids and molars the clamp generally may be utilized in place of the ligature. In some instances, however, it is a safer

plan to ligate the tooth, after which the clamp may be adjusted upon the tooth to be filled, or the one posterior to it. Waxed floss silk is generally used for ligating purposes. A piece cut sufficiently long for convenient handling is passed between the teeth, both mesially and distally of the one to be filled, the ends of the ligature extending labially or buccally; by means of a drawing movement the ligature and rubber are carried toward the root. At the gum border the edge of the rubber will be turned under by the movement of the ligature, after which the ligature may be removed, unless it is considered necessary, as previously indicated, to ligate the tooth. The adjustment of the ligature, in many instances, is a painful procedure, and permanent injury may be sustained by the gum and alveolar tissues, owing to the irritation initiated in the application of the dam and ligature. While these serious effects rarely occur, and very likely are associated with a predisposition of these tissues to diseased states, nevertheless a total disregard of the vital aspects of the tissues, necessarily irritated in the adjustment of the rubber and ligature, must be condemned, and the possible serious pathological involvement of these tissues, arising from a primary irritation, as indicated, is ever before the cautious practitioner.

THE CLAMP.—As previously stated, the clamp is used to secure the dam upon the molars. It also renders valuable service in preventing the rubber from being in the way of the operator, thereby materially advancing the convenience under which the operation may be performed. To be effective clamps must be constructed so as to be adaptable to the form of the teeth upon which they are intended for use. In a general way the modern clamp practically meets the requirements. Teeth with

short crowns, conically formed, which ordinarily favor the slipping of the clamp, may now be securely isolated with the forms devised to meet the requirements of these cases. The set of ivory clamps (Fig. 102) very effec-

FIG. 102

tively meets the needs of the practitioner. Other makes will also be found very useful.

Adjustment of the Clamp.—When the clamp is to be adjusted, and the one best adapted for the case has been selected, the dam is cut and punched, as previously indicated, and the perforation intended for the tooth to be clamped is stretched over the flanges (Fig. 103) at the sides of the clamp; the clamp forceps are next adjusted to the clamp, and the clamp placed over the tooth.

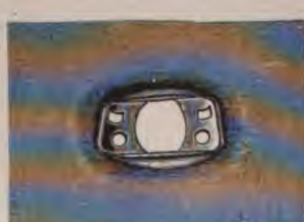

FIG. 103.—DAM AND CLAMP READY FOR ADJUSTMENT.

Care should here be exercised that the beaks of the clamp are not forced too far down in order that the patient might be spared considerable pain, also injury to the gum tissue. The tendency to place the clamp

too far down particularly exists in adjusting the clamp intended for conically shaped crowns, also for cavities extending along the cervical border of molars. When the clamp is in position the rubber is released from the flanges and adapted to the cervical part of the tooth.

Cervical Clamps.—This form of clamp is indicated for cavities extending along the cervical border and beneath the gum tissue. In no instance is it wise to force the adjustment of a cervical clamp, if in so doing the patient is made to endure agonizing pain. If the moisture cannot be excluded by other means less painful, another filling plan should be adopted. Very satisfactory results may be secured by means of the inlay method, utilizing Dr. Alexander's special gold as a means of making the inlay. Or, if the cavity is located upon the lingual surface of molars, gutta percha or amalgam may be used as the filling material. In all these locations it is better to force the gum tissue away from the cavity margin by packing the cavity with temporary stopping or gutta percha. This not only clearly exposes the cavity margins, but in many instances it also allows of the subsequent adjustment of the clamp without pain. Many operators prefer to avoid the obstacles and pain incident to the use of the cervical clamp by adjusting the dam and holding it away from the cavity border by an instrument in the hands of an assistant. Or the subgingival portion of the cavity may be filled with amalgam in molars, and crystal gold for the anterior teeth, excluding the saliva by means of absorbents. Later the dam is adjusted and the filling completed according to indications. Figs. 104 and 105 illustrate two useful cervical clamps.

The Saliva Ejector.—This is employed to carry off excessive accumulations of saliva, which may arise be-

cause of the patient's inability to swallow, or to an excessive flow following the reflex stimulation of the salivary glands. If the patient is unable to satisfactorily dispose of the amount of saliva poured into the oral cavity, either through inability owing to the position of the head, or any other cause that may interfere with the action of the muscles, unless the accumulation is carried off in some manner, it will drivel from the corner of the mouth, to the annoyance of both patient and operator. Under these circumstances the ejector is a very serviceable arrangement. Some patients object to the introduction into the mouth of the glass tube through which the saliva is drawn. The patient's consent is usually secured, however, if a satisfactory explanation can be made as to the method adopted for maintaining the part of the ejector placed in the patient's mouth in an aseptic state. A number of the detachable portions should always be on hand; these can be shown to the unwilling patient, and materially aid in securing his consent to their use.

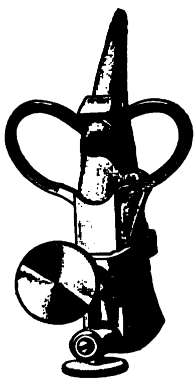

Fig. 104.—Ivory Cervical Clamp.

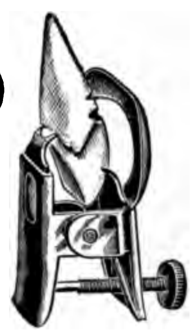

Fig. 105.—Keefe Clamp.

Fig. 106.—The Denham Shield.

The Denham Shield.—The Denham cofferdam shield or rubber cup (Fig. 106) may be utilized for the exclusion of moisture in various short operations. The

shield is adjusted by perforating its base with the rubber dam punch, and adjusting the cup upon a suitable clamp; this is placed upon the tooth, and the cup slipped over the flanges of the clamp, similarly to the method described in adjusting the dam upon molars. In operations upon the deciduous teeth, in the treatment of pulp canals, and in many occlusal cavities of the permanent teeth, the rubber cup may be advantageously employed.

Absorbents.—The use of absorbents is more generally relied upon for the exclusion of moisture from the field of operation than any other method. The ease of adjusting a napkin or roll of absorbent cotton no doubt, in most instances, is the factor which determines the means to be employed for maintaining dryness, and, although the operator may know beforehand that this method is not as effective as the dam method, the difficulties to be overcome in some cases of adjusting the dam, and the ease with which a napkin or cotton roll is placed, quickly influence the choice in favor of the utilization of the latter means for the exclusion of the saliva. This is compromising with the requirements of practice, and should be avoided. The consensus of opinion among the best operators is to the effect that an operation that is worth doing should be done in the best possible manner, and, in most instances, the best results can be secured only if the dam is employed for the positive exclusion of moisture. Certain operations, as, for example, the filling of occlusal cavities, especially in superior teeth, may be thoroughly performed without the use of the dam. But the effective exclusion of septic organisms is best attained in the use of the dam, and in proportion as the operation demands the exclusion of septic factors, in the corresponding ratio is the use of the dam indicated.

Previous mention has been made of the aptness attained by the older practitioners in the exclusion of moisture by means of napkins. Particularly effective was the system of napkining devised by Dr. J. Foster Flagg. Many who witnessed the clinical demonstrations given by Dr. Flagg adopted the method, and have found its application in many cases entirely satisfactory. Dr. Flagg suggested a napkin 16 inches long and 2½ inches wide, after the ends had been seamed. The napkin is folded first in half, and again in half, making four divisions.

For the superior anterior teeth the napkin is unfolded; a single layer extending from the corner of the mouth, on the far side of the tooth to be filled, is caught beneath the lip and turned upon itself to form a roll and carried beneath the farthest portion of the lip, where it is retained in position by the pressure of the lip against the gum; the rolled end, which has not been caught beneath the lip, is then carried to place, and it will be found to extend to the gum overlying the bicuspids; upon the other side it will also be found to extend to the bicuspids, if properly applied, with the long flat end extending out of the mouth. This flat end may be advantageously utilized in wiping the crowns of the teeth, or in any other manner that may suggest itself.

For the superior posterior teeth the upper corner of the first fold of the napkin is held obliquely at the corner of the mouth with the left hand; by means of the other hand the width of the fold is carried beneath the cheek until it rests well down upon the gum, and extends backward to the third molar. Subsequently the part of the napkin that projects from the corner of the mouth may be folded, and, similarly to the first fold,

applied to the parts. This yields a four-fold thickness of cloth as protection for the tooth against moisture. A second napkin may be inserted in the same manner, and, after the first fold has been carried to place, the first napkin may be withdrawn from the mouth without endangering the operation owing to the entrance of moisture.

For the inferior teeth the first fold of the napkin is placed at the middle of the mouth and carried backward to place between the cheek and gum tissue. This collects the flow from the parotid gland. The fold of another napkin is placed beneath the tongue to collect the saliva poured into this region. The ends of both napkins extend from the mouth, and may subsequently be utilized as indicated in relation to the superior teeth. The aseptic doilies supplied by the dental depots cannot be utilized as effectively as the napkins made after the measurements previously indicated, and of a washable material. However, they better meet modern sanitary views, and may be more acceptable for this reason to the patient.

CHAPTER XX

THE SEPARATION OF TEETH PREPARATORY TO FILLING

Definition.—By the separation of teeth as here considered is meant the creation of space by inserting a substance between the teeth which, by its resilience, a quality possessed by rubber, or by the absorption of moisture, which takes place when cotton or tape is used, or by the use of a mechanical separator, the teeth are forced apart, thereby creating space necessary for the correct restoration of carious teeth.

Since Dr. Black's presentation of his studies concerning the interproximal space, published in the *Dental Review*, 1890, showing its relations to the forms and contact points of teeth, the necessity for restoring the normal forms and contacts of teeth by means of filling has been emphatically impressed upon the profession. In order to secure these necessary results the preparatory separation of the teeth is imperatively indicated. Without this it is impossible to correctly reproduce the natural forms or contacts of teeth, and unless these are correctly restored the interproximal gum tissue cannot remain in a healthy state. The reader is referred to chapters dealing with the preparation and filling of cavities, and pyorrhea alveolaris, in which these matters will be found discussed more minutely.

Pathological Aspects of Separation.—While the changes which take place in the pericementum upon the application of force no doubt, in most instances, exceed

its physiological aspect, nevertheless we are so generally accustomed to view the procedure of separation as being within physiologic limits that we almost always ignore its pathologic features. And yet a momentary reflection ought to suffice to bring these clearly to view. The arrangement of the pericemental fibers is especially noteworthy for their effectiveness in guarding against displacement when stress is applied to the tooth. The fibers are of the inelastic variety, but these do not completely inhibit all displacement of the tooth. In fact, it is generally recognized that a slight movement is normal for each tooth. Through this, fracture is frequently averted, and a more effective comminution of food results. The act of providing space for the more thorough performance of operative procedures implies a movement beyond that which is normal for each tooth, hence exceeds the physiological aspects of the pericementum, and establishes a pathological condition proportionate to the excess displacement. This is confirmed by the tenderness upon pressure, indicating an arterial hyperemia, and is to be found, in greater or less degree, in all instances where the tooth has been displaced beyond its physiological capacity. Owing to the great reparative power of the pericementum, upon removal of the agent of separation, apparently the pericementum returns to its former normal physiological state. The tenderness upon pressure disappears, as well as any other evidence of circulatory disturbance.

But are we assured that, in all cases, there is a complete return of the pericementum to its former normal state? The scientific data at hand bearing upon this is exceedingly incomplete. The testimony of the orthodontist is entirely favorable to tooth movement, especially if undertaken in early life. But here again this posi-

tion is lacking in scientific confirmation. No investigations have been conducted upon teeth moved, as in orthodontic practice, or to meet other operative necessities, to determine if permanent changes follow the initial irritation. The resorptive function of the osteoclasts is more readily induced in some instances than others. We do not know at just what degree of irritation the functional activity of these cells may be excited in each individual case. It is quite possible that in separating teeth, in many cases, the osteoclastic function is inaugurated, while the teeth appear to have returned to their normal state. It is also quite possible that the hyperemic condition of the pericementum, in many instances, is followed by degeneration, and at a still later period by pyorrhea, which, however, is never traced back to the hyperemia induced by the separation. The procedure of separation should not be viewed in that indifferent attitude now so generally characteristic of the operation. Its possibilities for inaugurating serious pathological states should be seriously considered, and, until more scientific knowledge is at hand regarding these possibilities, it is best to carefully study every factor that may be of use in avoiding complications.

Classification of Methods.—Teeth may be separated by the *immediate* or *gradual method.* The utilization of either depends upon a number of factors, chief among which may be mentioned *the patient's susceptibility to and capacity for the endurance of pain; the firmness of the teeth in their sockets; the degree of separation desired.*

The Patient's Susceptibility to and Capacity for the Endurance of Pain.—The process whereby necessary space is secured for the filling operation should not be viewed merely as a mechanical procedure, depending

upon the use of the mechanical separator, or some other agent, but should be vitally related to the patient's physical condition and temperamental qualities. These factors should indicate the existing predisposition to pain and the ability for its endurance, and determine the method of the separation and the agents whereby it may be secured. It is manifestly unwise to adopt a plan of separation productive of pain, as usually occurs when the teeth are quickly separated, either with the separator or rubber wedge, if the physical condition or temperamental qualities of the patient are likely to cause failure in the attainment of the desired end. So, too, is it unwise to adopt a plan of slow separation with a pyorrheal tendency of the teeth; the extended irritation is more likely to prove harmful under the pyorrheal predisposition than a quicker method of separation. As previously stated, the process of securing space between teeth should at no time appeal to the practitioner only as a mechanical procedure. It should always convey its *vital relations,* in the thorough appreciation of which much injury and suffering may be avoided without the sacrifice of the necessary end in view.

The Firmness of the Teeth.—The fixation of the tooth in its socket has a bearing upon the method of separation to be followed. Teeth that are firmly planted in their sockets, such as usually are to be found in the sanguo-bilious, or bilio-sanguine, temperament, and where the *perceptivity* of the nervous qualities is lacking, may be separated by means of rubber, and wide separations secured, without incurring any serious risk. Furthermore, it must also be noted that, in proportion as teeth are firmly fixed in their sockets, so must adequate pressure be applied to effect the necessary degree of separation. In some of these cases the use of cotton, or tape,

would require an inordinate length of time to establish a satisfactory degree of separation, whereas in many cases where the teeth moved more freely in their sockets an adequate separation might easily be effected with either substance.

The Degree of Separation Desired.—This has a definite relation to the method of separation to be employed. If the space to be created depends upon the resilience of rubber, or the absorption of moisture by cotton, or upon the use of the separator, a limit is reached beyond which the agent of separation cannot pass; if this is within the requirements of the case, no concern with further separation is necessary. If, however, the separation proves to be inadequate, additional space must be formed. This may be secured by means of the mechanical separator, after the teeth have been inadequately moved apart by some other agent. In other instances the space to be created might easily be effected by the use of cotton or tape; therefore, it would be uncalled for to utilize any other agent, as in so doing greater irritation to the tissues might ensue. Occasionally cases present where the desired separation can be secured with the separator without the preliminary separation first formed by the use of some other agent. In such instances it is not good practice to unnecessarily irritate the tissues, and inconvenience the patient, by inserting a substance between the teeth for a preliminary separation.

Immediate Separation.—This is best accomplished by means of the mechanical separator. At times the wooden wedge may be utilized for an immediate separation of the anterior teeth, but the result is never as positive as when the separator is utilized. The Perry separator is generally regarded as more satisfactorily meeting the

indications than any other form of separator. Fig. 107 illustrates the set consisting of six forms. These are

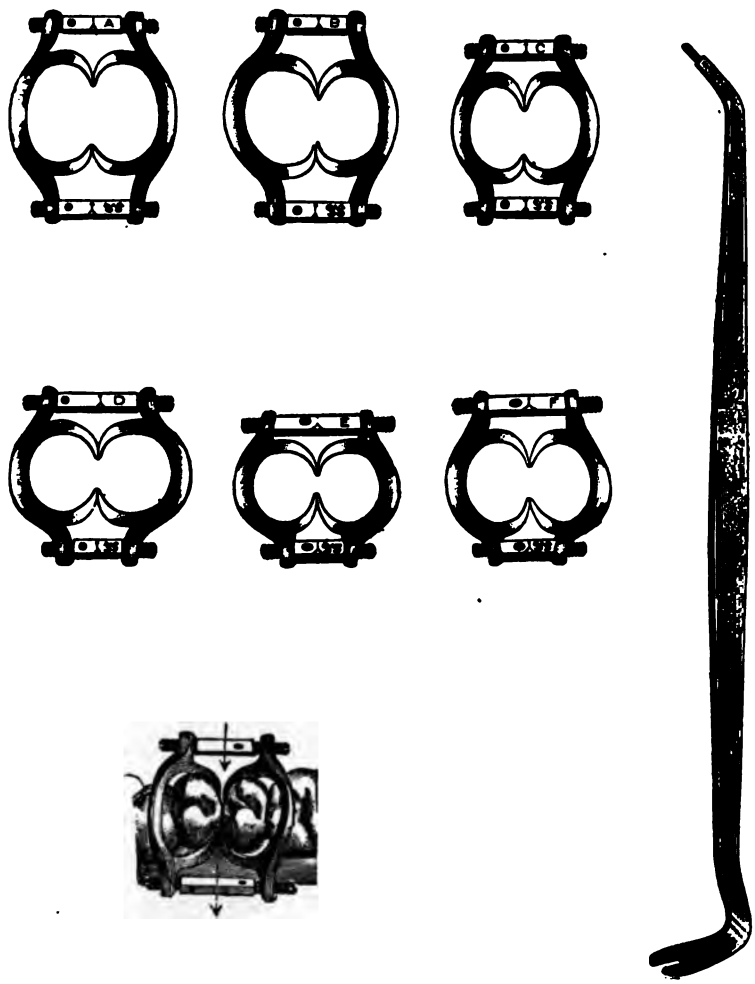

FIG. 107.—PERRY SEPARATORS.

designed for use in the posterior, as well as anterior, parts of the mouth.

The following advantages result from the use of the separator:

First.—In making examination for cavities of decay.

Second.—In prophylaxis work it enables the operator to immediately remove stains from the proximal surfaces.

Third.—For the insertion of wedges, gutta percha, cotton, etc., when space must first be provided.

Fourth.—As the most important factor in securing the necessary space for the proper filling of all cavities involving the proximal surfaces.

Fifth.—By firmly holding the teeth apart after the desired space has been created, it prevents the painful impact of the condensing force, in many instances enabling the operator to complete the filling operation, which, without the aid of the mechanical separator, could not be completed unless the tissues first recovered from the irritation present.

Sixth.—As an aid in providing space for the proper finishing of fillings, and the formation of a proper contact.

These are the more important advantages accruing from the use of the mechanical separator. The operator may easily discover others. These may appear in its use in special cases, and at times the most valuable form of service may be rendered by the separator, not to be secured by any other means.

Emphatic as the evidence may be in support of the superior service rendered by the mechanical separator, it must not be overlooked that its injudicious use may be followed by serious consequences. The temptation to provide space which may yield greater convenience for the introduction of the filling may induce an irritation in the alveolar tissues followed by permanent injury. Then, again, the points of the separator may impinge upon the gum tissue, and cause considerable pain

and injury to the interproximal tissue. Due regard should be given to any evidence of pain the patient may indicate. It is not wise to force the separation beyond this, for fear of injury to the tissues, as stated, and for fear of straining the patient's compliant disposition, which might interfere with the subsequent use of the separator.

Gradual Separation.—This is secured by means of such agents as cotton, tape, gutta percha, wood, rubber, etc. Antagonizing views have been expressed as to the value of these different materials when used for the purpose of separation, also as to the methods to be followed. Dr. Garrett Newkirk[1] writes as follows: "The writer will say at the outset that the longer he continues in practice the less he depends on very slow wedging for the separation of teeth. He is more fearful than formerly of inflicting permanent injury to the tissues involved, viz., the pericemental membranes, the interproximal alveolar wall, and the overlying gums." It would be well if the warning contained in the above statements would be impressed upon all practitioners. Too frequently permanent injury follows an injudicious plan of separation, and no doubt many such instances arise which are never etiologically associated with the method of separation previously practiced. On the other hand, it must not be overlooked that permanent injury may follow the immediate method of separation. The ease with which the separating bars of the separator may be turned conduces to a too forcible widening of the teeth; the apical vessels may be injured, followed by thrombosis, and later by devitalization of the pulp. The pericemental membrane may also suffer permanent injury from the too severe compression and stretching of its

Johnson's "Textbook of Operative Dentistry."

fibers. Therefore, while the gradual method of separation may lead to serious pathological involvement of the tooth, the immediate method may be followed by a like involvement if injudiciously practiced. As previously stated, the patient's susceptibility to, and capacity for, the endurance of pain, the firmness of the teeth in their sockets, and the degree of separation desired should be carefully considered, after which the method best adapted for the case at hand should be selected and thereby the necessary separation established.

Cotton.—This acts by absorbing moisture and usually produces the desired degree of separation with but slight tenderness of the tooth. For this reason both cotton and tape are extensively utilized in making separations. Either agent is indicated where the teeth are not too firmly planted in their sockets, and where a milder degree of pressure is indicated, owing to the patient's intolerance of pain. Dr. Jack[1] regards the use of cotton as being more appropriate for the posterior teeth; here the pledgets may be packed with considerable pressure when no pulp exposure exists. If the cotton is utilized in a cavity of decay during the separation, it is likely to induce a hypersensitive state of the tooth structure owing to the fermentation set up by the masses of bacteria which find a resting place in its fibers. The acid created by the fermentation process induces the hypersensitive condition of the tooth structure. For this reason it is better to close the cavity with temporary stopping prior to the introduction between the teeth of the cotton, and, while more time may be required for adequate separation, this is preferable to the serious inconvenience to both patient and operator, that may arise if the precaution is not taken.

[1] "American Textbook of Operative Dentistry."

This hypersensitivity of the tooth structure does not develop nearly so readily when tape is used as the separating medium, and most likely is due to the fact that it does not enter the cavity as easily as cotton; hence, if fermentation takes place, the acid is more likely to be washed away by the saliva, and does not affect the tooth substance.

Gutta Percha.—Gutta percha, or the red gutta percha base plate, may be utilized to effect separations. This it usually does slowly, but also painlessly. The material is used when a cavity of decay is to be temporarily closed, and is especially indicated if the gum tissue has extended into the cavity, or if it is to be forced away from the gingival border of the cavity. The separation which gutta percha is capable of effecting is due to its elasticity; therefore, the more it is compressed the better the separation. To secure this result the teeth should be primarily separated with the mechanical separator, and when a slight separation has been obtained by this means, the gutta percha may be forcibly packed into the opening, and, when cooled, the separator removed. Dr. Bonwill originally suggested the use of the red gutta percha base plate between deciduous teeth, in those instances where lateral expansion appeared to be desirable. (See chapter on Treatment of Deciduous Teeth.) The force of mastication acting upon the material would gradually separate them. In following this plan, the precaution of protecting the interproximal gum tissue by inserting a piece of stiff plate to extend from cavity to cavity must be taken, otherwise irreparable injury may follow the pressure of the material upon the gum. Then, again, the condition should clearly indicate the desirability of lateral expansion, or the normal occlusion of the teeth may be destroyed.

Wood.—Orange wood may be employed to effect separation of teeth in certain cases, such as, for example, where sufficient immediate separation cannot be secured by means of the separator, and where rubber is contraindicated owing to the patient's marked intolerance of pain, and where cotton, or tape, cannot be conveniently or effectively employed. In these instances the separator may be adjusted and turned to slightly separate the teeth. Into this space a wooden wedge is forced and the separator removed. This secures the wedge in place, and by its absorption of moisture additional space is gained.

Rubber.—The use of rubber affords probably the most efficient means of making separations. The objections to its use arise from the pain which almost invariably accompanies the separation, and the injury to the interproximal gum tissue that is so likely to take place. As the teeth separate the rubber is forced into the wider space, and against the gum tissue, which it severely irritates. If this persists the gum tissue may fail to again normally occupy the interproximal space, and the alveolar septum may also sustain permanent injury. If, in inserting the rubber, it is allowed to project beyond the occlusal surface, it is not likely to injure the gum tissue, but the inconvenience to the patient is increased, due to the interference which the projecting wedge offers to occlusion. In many instances where rubber has been used as the separating medium the pericemental irritation is so severe, that to subject the tooth to the additional irritation of any operative procedure at the time is liable to result in severe pathological manifestations. In these cases the indicated treatment is to insert gutta percha into the space, and allow the irritated tissues to recover before proceeding.

Dr. Jack[1] suggests the use of white rubber tubing as a means of making less painful separations than can be accomplished with purer grades of rubber. The white rubber tubing is an adulterated variety with its resilience reduced; hence, separations can be effectively made with greatly lessened, and in many instances without, pain.

In conclusion, it may not be amiss to again emphasize the importance of *vitally* considering the procedure of separation, and not merely as a mechanical act. Here, as in the treatment of hypersensitive dentin, the ability to attain the desired result in many cases depends more upon the sympathetic attitude of the operator than the materials and methods to be employed.

[1] "American Textbook of Operative Dentistry."

CHAPTER XXI

ORAL HYGIENE

Definition.—Oral hygiene signifies the science of the health of the mouth and of its preservation.

General Relation to Health.—It is now quite generally contended, and apparently with considerable basis in fact, that the condition of the oral cavity is a factor of importance in relation to the health of the individual. The observations of a number of investigators have strengthened the belief that not only many of the disorders of the gastrointestinal tract and the complications arising therefrom have their origin in a defective and neglected state of the oral cavity, but that in some instances a disturbed balance of the higher nervous centers may be reflexly inaugurated by a septic condition existing at the end of a root by impacted teeth, or by a chronic irritation of the pulp. In view of these facts the necessity for the early practice of measures intended for the maintenance of the oral cavity in a state of health is quite obvious. If, at the period of birth, the oral cavity through neglect becomes the seat of infective processes, and if these are allowed to go on uninterrupted, the health of the child may soon become dangerously involved. The high rate of mortality affecting infants is in a significant manner related to gastrointestinal disorders, some of which, at least, are etiologically associated with neglect of the oral cavity. Within a few months after birth the effects of dentition are likely

to appear in the mouth, in a hyperemic gum, pain when pressure is made upon the swollen gum tissue, excessive flow of saliva, etc. During this time the necessity of maintaining a satisfactory state of oral hygiene becomes even more imperative. The hyperemic gum tissue generally means a lessened buccal resistance, and this is favorable for bacterial activity in proportion to its diminution. Unless careful measures are put in force for the arrest of bacterial activity, the complications that may arise are likely to prove a dangerous factor in the battle for life. During the periods of the eruption of the deciduous teeth, and especially those following, important formative changes are taking place in the surrounding structures. Reflexly and directly these may be abnormally influenced, owing to the inauguration of pathological processes within the mouth, in part, at least, associated with a lack of oral hygiene.

Unsettled as the question of caries of the teeth may be, especially in regard to our knowledge concerning the conditions of *immunity* and *susceptibility*, sufficient light has been thrown upon the related factors of its etiology to warrant the positive statement that, if the oral cavity could be maintained free of bacterial habitation, caries could not possibly occur, irrespective of the high degree of susceptibility to the caries fungi existing at any time. While we cannot possibly establish for any length of time by any known means this ideal state of the oral cavity, prophylactic measures, as well as oral prophylaxis, will materially aid toward it. The argument occasionally advanced that the many instances of extreme susceptibility to caries, in the presence of the enforcement of what are usually regarded as satisfactory preventive measures, and the many instances of immunity to caries, in the entire absence of these meas-

ures, negative their value, is foolish and incomplete. A far greater number of cases can be shown in which the maintenance of a hygienic state of the mouth was followed by a notably lessened susceptibility to caries, irrespective of which the positive value secured in preventing the ingress of multitudes of bacteria, and a greater or less amount of toxic products, alone warrants at any cost the enforcement of all measures whereby a suitable oral hygiene can be maintained.

Reference has previously been made to the high death rate among infants, and the relation which this bears to gastrointestinal disorders, originating in some and aggravated in others through oral neglect.

Oral Hygiene in Pathological Conditions.—The gastrointestinal disturbances, in most cases, are reflected in a form of *stomatitis,* and whatever form this may assume, oral neglect must adversely influence all efforts at systemic treatment. A brief discussion of *stomatitis* may follow here, as it presents a group of disorders appearing in adults as well as infants, demanding the application of those local measures tending to establish a suitable hygienic condition of the mouth.

Simple Follicular Stomatitis.—This is an inflammation of the mucous follicles and is frequently found in artificially fed children, generally due to unclean nursing bottles and nipples, also to an incorrect food supply. It also appears in adults addicted to the smoking habit or the use of excessive amounts of alcohol. The disease manifests itself in bright red spots which finally merge, producing a swollen, red surface, painful to the touch. The child is fretful and irritable, usually feverish, is attacked with vomiting, and shows irregular bowel action. In later stages the mouths of the mucous follicles degenerate and slough. The mouth becomes

parched, following the active interference with the blood supply.

Ulcerative Stomatitis.—This is an inflammation of the mucous membrane followed by degeneration, necrosis, and ulceration. The breaking down of the tissue may occur in any location, and with the appearance of the ulcers we find a heavily coated tongue, salivation, fetid odor of the breath, and considerable pain when the ulcer or the surrounding tissue is touched. Fever is usually present, also swelling of the glands in the region of the angle of the jaw. When the disease occurs in children, a history of incorrect feeding and lack of oral hygiene is usually obtainable, although it may occur through other sources. It may follow a simple follicular stomatitis, or it may follow a *mercurial* or *syphilitic stomatitis.*

Aphthous Stomatitis or Herpetic Stomatitis.—This condition is distinguished by the appearance of an ulcer upon the tip or side of the tongue, more commonly upon the cheek and gum tissue. As a rule, a degree of simple stomatitis accompanies its appearance. There is an increased flow of saliva, a coated tongue, and a heavy breath. When the ulcer is touched by food in eating, or with the tongue, great pain is experienced. Some systemic disturbance is usually noticeable when the aphthæ appear, generally referable to a disturbed digestive system. Fever may accompany the disease. Dr. George H. Wright,[1] in discussing this condition, quotes Drs. Holt and Forchheimer as to the etiology of the disorder, and states that these observers agree that it is of nervous origin. From close observation covering many cases the writers believe the appearance of the aphthæ to be due to the attempted elimination by the

[1] "Textbook of Operative Dentistry," Johnson.

buccal mucosa of some toxic product retained in the circulation, in most instances, because of an hepatic disturbance. Usually a plàn of treatment intended to restore normal liver action is the surest method of restoring the normal aspect of the oral cavity, supplemented by local treatment, and of preventing the appearance, so long as the liver action remains normal, of additional aphthæ.

Thrush or Parasitic Stomatitis.—A form of stomatitis occurring mostly in children, due to the development of the fungus known as *oidium albicans,* or *saccharomyces albicans,* a member of the yeast variety of fungus. It is claimed that it does not grow on normal mucous membrane.[1] Conditions of malnutrition, or dyscrasic states, combined with lack of oral cleanliness favor the appearance of this disease. It is characterized by the appearance of minute white and yellowish spots or patches, covering the palate, tongue, and cheeks, and if a scraping is placed beneath the microscope the fine threads (mycelium) and small oral spores leave no doubt as to the diagnosis.

Infantile Scurvy.—This condition may here also be briefly noted, not only because it indicates the utilization of similar oral measures to those employed in the pathological conditions previously noted, in order to assist in establishing a hygienic state of the mouth, but also because the condition occasionally is wrongly diagnosed as *pathological dentition* (see Pathological Dentition), the treatment for which must be followed upon entirely different lines. *Scurvy* is a disease essentially due to the absence of a certain nutritive element, and whether this is due to the deficiency alone of potash in the system, as the experiments of Dr. Garrod appear

[1] Tyson, "Practice of Medicine."

to show, or to some other nutritive material which, when combined with potash, proves corrective of the pathological manifestations of the disease, or whether the disease is due to infection, as others maintain, need not be discussed here. The factors of present interest are to be found in the symptomatology of the disease, through which it is to be distinguished from *pathological dentition,* and its treatment in relation to oral hygiene. In discussing *pathological dentition* attention was directed to the error in diagnosis that may, at first view, easily be made between the two conditions. A scorbutic child is usually pale and emaciated; the pulse and heart action are feeble; the temperature, usually normal, may be slightly elevated. The child is irritable and fretful and may be attacked with vomiting and diarrhea. It is in the appearance of the *gums* that the error in diagnosis is usually made. These are considerably *swollen* and *spongy,* and bleed almost upon the slightest touch. This at once suggests the presence of a tooth in the tissues beneath the gum as the cause of the disturbance. In scurvy, however, hemorrhages beneath the skin appear, usually first in the lower, later in the upper extremities and trunk. These extravasations of blood are slow to disappear, and are wanting in pathological dentition. With the internal administration of the organic acids such as citric, mallic, etc., the pathological manifestations of the disease quickly disappear; as an aid in the recovery of the markedly hyperemic gum, solutions of boric acid, hamamelis, or any of the antiseptic solutions upon the market will be found to be of value.

Other Pathological Conditions.—Clearly as the preceding conditions call for the various measures relied upon for a corrective effect of the oral pathological manifestations, supplemented by general therapeutics when

the conditions warrant such procedure, the oral neglect from which stomatitis frequently originates may lead to more serious complications by involving the teeth in a pyorrhetic state terminating in their loss, and by inducing grave systemic disturbances etiologically associated with oral sepsis. Hunter, in his work on "Oral Sepsis as a Cause of Disease," states that pericarditis, neuritis, and septicemia are caused by oral sepsis. Dr. Osler states that defective teeth are responsible for more widespread physical disabilities than alcohol. The investigations of Dr. Henry S. Upson, of the Western Reserve University, are now quite well known to the members of the profession. The views of these observers are confirmatory of the serious systemic effects originating from lack of oral hygiene, and defective teeth.

In the chapter on Pyorrhea Alveolaris, in discussing its etiology, the effects of oral neglect are noted in detail, and special emphasis is laid upon the necessity for a suitable oral hygiene as a means of avoiding the disastrous results that may follow when food débris and masses of bacteria are allowed to remain between and around the teeth. Fermentative and putrefactive changes quickly ensue, and the toxic products not only induce gingivitis, alveolar and pericemental degeneration, necrosis, and loss of teeth, but similar poisonous substances enter and irritate the gastrointestinal tract, in many instances producing pathological effects throughout the system that only recently have been recognized.

In a paper entitled "Six Years' Work in Oral Prophylaxis," presented before the New Jersey State Dental Society by Dr. D. D. Smith, and printed in *Items of Interest*, January, 1905, the following appears:

"We have abundantly proven that diabetes and many gastrointestinal troubles are directly traceable to the mouth infection of alveolar pyorrhea; also that many pharyngeal and tonsillar inflammations and many skin troubles have their origin in infection in the mouth, due to septic states of neglected teeth. We know, also, that mental depression and hypochondria, and many of the perplexing nervous conditions in women, result from the same cause."

These conclusions, as previously stated, have been corroborated by members of the medical profession.

Establishment and Maintenance of Oral Hygiene.—The positive establishment of these facts, not only by the evidence of one, but of numerous sources, attaches at the present time a far greater importance to the practice of those means whereby oral hygiene is successfully maintained than could be claimed for it in the past. This is entirely due to the increased *vital appreciation* of the teeth and their environments, gradually developed, as previously indicated, by showing the pathological sequelæ that may follow oral neglect; also by the benefits that surely accrue when the teeth are in a normal state, and normally, or physiologically, put to use in the act of mastication. For this latter knowledge we are indebted to Mr. Horace Fletcher. He has shown that the function of mastication properly performed is more vitally important than heretofore suspected, or, if so considered, no one before Mr. Fletcher has so emphatically insisted upon the thorough *mastication* and *insalivation* of food, prior to its passage into the stomach, as a necessary prerequisite to the maintenance of a normal vital standard. If mastication and insalivation are not physiologically performed, the normal vital balance, sooner or later, must be lowered. A lowered vital balance

means diminished buccal resistance, and this is but a step removed from disease. The science of the health of the mouth, therefore, signifies the utilization of means adequate for the preservation in a state of health of the oral tissues, inclusive of which is the physiological use of the teeth.

In the paper by Dr. Smith, previously referred to, a distinction is made between the two terms "*prophylactic*" and "*prophylaxis*." Prophylactic is defined as relating to *remedies* which may be utilized in preventing or protecting from disease. Prophylaxis implies the surgical *art* or *treatment* as a means of prevention of disease. Hence, oral prophylaxis means to treat the teeth surgically, as in the removal of the various deposits; the use of a germicidal wash, on the other hand, being a form of prophylactic treatment. Both measures are utilized in the development and maintenance of oral hygiene.

With the first nursing the young infant receives, hygienic measures should be adopted to guard against infective processes, which, if allowed to develop through neglect, may prove to be a serious menace to its life. For this purpose nothing answers better than a solution of boric acid. Sterilized gauze is to be wound about the index finger, which previously has been made aseptic, dipped in the solution, and the mouth thoroughly swabbed after each feeding. This simple prophylactic precaution will most likely prove to be entirely efficient in maintaining a healthy state of the oral cavity in ordinary cases. In bottle-fed infants adequate precautions must be taken in regard to the nipples and bottles, and the prepared food must be correctly adapted to the requirements of the infant. If either are at fault stomatitis and gastrointestinal irritation are sure to follow.

In the treatment of stomatitis arising from the causes just mentioned, these must be removed as a necessary preliminary to the local treatment. The nursing bottles and nipples must be sterilized, and maintained in a sterile condition; or, if the stomatitis appears to be due to a gastrointestinal irritation developed because of an improper food supply, this must be promptly modified to meet the infant's requirements. The correction of these faults is in itself likely to lead to correction of the oral disease. It is prudent, however, to render aid by the use of suitable antiseptic solutions. Boric acid, 10 to 15 grains to the ounce of water, is of value, or 15 grains of chlorate of potash dissolved in a half ounce each of hamamelis and water is also an excellent solution. The following combination will be found especially efficacious:

℞	Boric acid	ʒiss
	Formalin	m. xv
	Thymol	grs. xx
	Menthol	ʒi
	Gaultheria	m. xxv
	Glycerin	℥ss
	Alcohol	℥i
	Water dist. q. s.	℥viii

M.

A piece of sterilized gauze is dipped in this solution and passed over the mucous membrane of the mouth.

In cases of ulcerative conditions the use of cauterants, especially silver nitrate, has proved to possess little value in the experience of the writers, notwithstanding its high endorsement in many quarters. Removing the cause whenever possible, together with the use of non-irritating antiseptic solutions, also possessing

astringent and mild anodyne properties, has in most instances been followed by early recovery. In adults the ulcerative areas may be touched with a 1 per cent. solution of cocain or other anesthetic solution. This will afford great relief from the distressing pain at times experienced, when the side of the tongue is affected, and each act of speech or mastication is accompanied by severe pain. Antiseptic precautions should also here be vigorously enforced.

Aside from the attention to the correction of the digestive disturbance, or the retention in the system of some waste, owing, most likely, to a sluggish and incomplete hepatic function, attention should also be given to an atonic condition, for which suitable tonics and alteratives are to be given. To what extent the dental practitioner may make recommendations and prescribe for the different varieties of stomatitis cannot be here discussed. It is quite evident that he should be fully conversant with the pathogeny of these affections, as well as the therapeutics, that an efficient oral therapeusis may be enforced. It is not prudent to trespass upon the domain belonging to the physician; therefore, those forms of stomatitis which require general attention should be referred to the physician for general treatment.

Important as the preceding pathological conditions may be in relation to oral hygiene, the pyorrheal affections of the teeth obviously are more important. Not only is it necessary here to consider the presence of various classes of microörganisms, the various toxic products elaborated, extending the inflammatory process about the oral tissues, entering and irritating the gastro-intestinal tract, producing serious systemic derangements, as previously noted, but the loss of the teeth

which, sooner or later, follows pyorrheal affections, if allowed to go on without effective treatment, presents an additional factor of pathological complication, now receiving increasing consideration. It may be repeated that these facts are, at the present time, known to a greater number of people, more vitally appreciated by them, and hence a greater importance attaches at the present time to the general subject of oral hygiene than at any time in the past.

For the detailed consideration of pyorrhea alveolaris the reader is referred to the chapter in which the subject is discussed. The dissimilar views as to the etiology of pyorrhea are as obstinately defended to-day as ever before, but, in so far as oral hygiene is related to the disease, not one dissenting voice has ever been heard against the necessity of its strict enforcement as a factor of great importance in the applied curative efforts, irrespective of whether the case under treatment is viewed as being of local or systemic origin. Years ago Dr. Riggs insisted upon the thorough removal of all deposits found upon affected roots as a necessary procedure, without which recovery could not be realized; and no doubt other measures tending to promote oral hygiene were enforced, perhaps equally as effective as those of the present day.

For the pathology and etiology of calcareous deposits the reader is referred to Chapter XV (Diseases of the Pericementum).

Many instruments have been devised for the removal of deposits from the roots of teeth. No fixed or unvarying rule can be expressed for the use of certain forms. As noted in discussing the treatment of pyorrhea alveolaris, each operator inclines to the use of certain forms, and in his hands these best meet the in-

dications. During the act of removing the deposit from the root the parts are frequently sprayed with an antiseptic solution, which materially aids in freeing the tooth of adhering masses of bacteria, septic products, and food detritus. The deposits should be completely removed from one tooth before proceeding to the next, so that no secondary effort in this regard should interfere with the reparative efforts most likely taking place in the pericementum and gum tissue. The sooner these tissues are restored to a condition of health, the sooner oral hygiene may be established. The removal of the deposits is followed by the thorough polishing of all the surfaces of the teeth. Dr. Smith insists that this should be done by *hand methods. Power polishers should never be used.* Orange-wood points in holders, charged with finely powdered pumice, and the movement of the hand are the means employed for the prophylaxis treatment, which, when persisted in for a sufficient length of time, according to the requirements of the case, is capable of effecting the wonderful changes described by Dr. Smith as follows:

"The osseous structures, after a few months, exhibit unmistakably a marked change for the better, and in most cases they become wholly immune to decay. The vital forces within the tooth—the pulp—and those surrounding it—the pericementum and its connections—are stirred and stimulated to new life and activity. Circulation in dentin and enamel is revived and quickened; old stagnant colors and deposits are manifestly taken up and removed, and new, fresh material deposited in place of them."

The prophylaxis treatment extends over a period of from three to six months, repeated as frequently as the judgment of the operator may indicate. This simple

means, as described, is emphatically endorsed in numerous quarters as being entirely adequate to establish an ideal hygienic state of the mouth. Pyorrheal affections are arrested and finally destroyed. The gum tissue is restored to its normal healthy aspect, and the septic products so actively formed in the mouth, characterized by lack of hygiene, are no longer elaborated, and the local and systemic effects so likely to follow the presence of these various toxic agents are no longer visible.

These changes are possible by means of the prophylaxis treatment, and when finally established can only be maintained by an intelligent utilization of methods adequately described and impressed upon the patient by the operator. Foremost among these is the efficient use of the tooth brush. Patients frequently inquire as to how often the teeth should be brushed. Once a day may prove adequate in some instances; in others, three or four times a day may be necessary for a satisfactory state of oral cleanliness. It depends upon the oral predisposition to fermentative and putrefactive changes, the facility with which microbic plaques are formed, and the favorable conditions that may exist for the retention of food débris. Furthermore, much depends upon the degree of effectiveness attained in the use of the brush. This does not depend upon the direction of the movements of the brush. Whether it be in an up and down or lateral movement, either may be perfected to yield eminently satisfactory results, in so far as the brush can be made to yield satisfactory results. The patient should be instructed that the end sought in the use of the brush is the removal of all foreign substance that may collect upon the surfaces of the teeth, and a frictional effect upon the gum tissue intended for its stim-

ulation and vital development. In order to secure this the brush should be passed over the surfaces of the teeth and over the gum margins, with a movement most convenient to the patient, until all depositions appear to be removed, and the gum tissue slightly smarts from the frictional effect of the brush. Dental floss may then be carefully passed between the teeth to dislodge deleterious agents clinging to the proximal surfaces. This is rarely, if ever, accomplished in the use of the brush, and, therefore, constitutes an important feature of the treatment performed by the patient. When the contact point and the remaining portion of the surface have been cleansed in this manner, the patient may rinse the mouth with a 25 per cent. solution of one of the antiseptic preparations upon the market. This frees the oral cavity of masses of bacteria, food débris, and the products of bacterial activity, and, in the writers' judgment, constitutes a valuable aid in the effort to establish oral hygiene.

Dr. Smith, in the article previously referred to, logically advises the brushing of the teeth *before meals,* arguing that, as septic materials gather upon the teeth in the interim between meals, brushing the teeth as recommended removes the toxic substances and prevents their entrance into the gastrointestinal tract. After meals efforts should be made to remove particles of food remaining between the teeth and along the gum border. This is an important recommendation to be made to the patient, increasingly so in proportion to the oral predisposition to bacterial activity. The removal of the food débris is effected by means of toothpicks, and rinsing the mouth with an antiseptic solution, or water, if the former is not at hand. The thorough removal of food particles inhibits bacterial activity, and prevents

the formation of odorous and irritating products; therefore, the utilization of the means whereby this is effected should be emphatically encouraged. Before retiring at night the same preventive measures should be employed, otherwise the bacteria present in the oral cavity may still be capable of effecting changes in mucoid collections upon the surfaces of the teeth during the hours of rest that follow, with no buccal or lingual movements or salivary washings to disturb their activity. In other words, the bacterial cells, similar to all other living cells, require, among other conditions, an adequate food supply in order to normally perform their vital functions; when this is lacking their vital behavior is inhibited, and the toxic substances otherwise formed by them are absent. It may be a physical impossibility to remove all bacteria from the oral cavity, or to chemically destroy them, without destroying the living cells of the mouth, but we are capable of rendering their environment unfavorable for serious manifestation of their vital activity, and the thoroughness with which we remove food particles, etc., and the bacteria as well, from the mouth by means of the brush, toothpick, floss-silk, and the use of antiseptic solutions in a large measure determines the control over bacterial activity, and the formation of noxious products, horribly offensive and poisonous as some of them are, as previously indicated, others destructive to the teeth.

When a satisfactory state of oral hygiene has been developed, and the patient forcefully impressed with the necessity of following the instructions imparted to him, if the hygiene of the mouth is to be permanently maintained it must also be stated that the prophylaxis treatment must be repeated, at stated intervals, as the case may demand, otherwise the effects of the expended ef-

forts will be lost. If this is not enforced the gum tissue will again give evidence of its hyperemic state, the breath will become heavy and offensive, the teeth tender when bitten upon, due to the irritation of the rapidly forming calcareous deposit, and toxic substances elaborated through bacterial activity, and the series of gastrointestinal and other derangements that may have previously existed again will surely develop if, through failure of the patient to avail himself of the prophylaxis treatment as advised by the dentist, the causes of the pathological states indicated again become operative.

Gum massage is favored by some oral hygienists, claiming that it makes the tissue hard and firm and improves its circulation. The claim is also made that it checks recession, and, in many instances, if the massage treatment is persisted in it will induce the gum tissue to return to its normal position in relation to the tooth. How well these conclusions are founded has not been scientifically established. That the firmness and circulation of the tissue are likely to be improved by the massage treatment is a very acceptable conclusion. That the gum tissue may be made to resume its normal anatomical relation with the tooth, following the treatment, has not, to the knowledge of the writers, been scientifically demonstrated.

A factor of undoubted value, and one assuming increasing importance, in impressing upon the patient the necessity for the exercise of all measures whereby a state of oral cleanliness may be maintained, lies in the sanitary surroundings of the operator. If these are developed as they should be, an excellent precedent is set before the patient, emphatically arguing for the

adoption of every means interpreted as a factor of cleanliness. In their absence the most eloquent appeals the operator may make as an oral hygienist lack in the element of conviction, and will end in failure in serving their purpose.

CHAPTER XXII

THE DISCOLORATION OF TEETH

Definition.—The loss of the natural color effect of a tooth, due to the penetration of the intertubular tissue or of the tubes by insoluble substances which impart their distinctive hues to the tooth substance.

Causes of Discoloration.—The discoloring substances originate from the following sources: (1) From the vascular supply of the pulp; (2) from the decomposition of the pulp; (3) from therapeutic applications; (4) from metallic salts formed by the action of corrosive agents upon fillings or instruments, or otherwise formed.

(1) The Vascular Supply of the Pulp.—If from any cause (see chapter on Diseases of the Pulp) dilatation of the vessels of the pulp takes place, followed later by its death, the disintegration of the red blood cells is likely to occur, and the released hemoglobin penetrates the dentinal tubes, giving the tooth a light pinkish hue. Dr. E. C. Kirk writes regarding this as follows:

"It is now known that the pink staining of the tooth is brought about by a rupture of the stroma of the red blood disks liberating their contained hemoglobin, which dissolves in the plasma, forming a solution of hemoglobin which readily penetrates the dentinal tubuli, the lumen of which is of insufficient diameter to admit the unbroken red blood corpuscle. This pink discoloration resulting from the infiltration of hemoglobin solution represents the first stage of tooth discoloration. The

pink stain readily undergoes alterations, later on assuming a brownish tint, due to the breaking down of the highly complex molecule of hemoglobin into a reduction product known as hematin."

Dr. Kirk[1] also believes that the character of the pulpitis determines the rapidity with which subsequent changes take place. The mild cases of vascular disturbance, followed by a slow necrotic process, may show immediately after death of the pulp such slight color change as to make it unrecognizable, except when special means of illumination are utilized, and even then but a slight opacity may be detectable. In these cases, however, the discoloration becomes more marked, and eventually calls for correction. In the severe cases of vascular disturbance, especially in teeth which have suffered a sudden and violent death, as from a blow, or other form of trauma, the pinkish discoloration may be very pronounced. The older writers have spoken of this condition as *suffusion,* and the subsequent changes here also are likely to be more impressive.

(2) DECOMPOSITION OF THE PULP.—The putrefactive decomposition of the pulp is generally regarded as being the most prolific source of tooth discoloration. The process of pulp decomposition (see Moist Gangrene of the Pulp) is the splitting up of the complex nitrogenous compound into simpler products through the agency of microörganisms. A series of intermediate and end products are formed, the most important of the latter being ammonia, NH_3, and hydrogen sulphid, H_2S. The hydrogen sulphid is generated in the presence of hemoglobin. Many writers deduce from this that ferrous sulphid, FeS, is formed, and that this is the agency

[1] "American Textbook of Operative Dentistry."

through which the process of subsequent discoloration of the tooth takes place.

This is the position assumed by Dr. E. C. Kirk, who is regarded as having given more study to the problem of tooth discoloration than any other writer. In the chapter on Discolored Teeth and Their Treatment, written by Dr. Kirk, for the "American Textbook of Operative Dentistry," this writer makes the following quotations, apparently in support of the view that ferrous sulphid is formed in the putrefactive decomposition of the pulp, by the union of hydrogen sulphid with the iron of the red blood corpuscles, and that this product is chiefly concerned in bringing about the subsequently noted discoloration of the tooth:

"Miller says: 'If a current of sulfuretted hydrogen is conducted through fresh blood, or a solution of oxyhemoglobin in the presence of air or oxygen, sulfomethemoglobin is formed, which is greenish-red in concentrated solutions and green in dilute solutions. If we lay a freshly extracted tooth in a mixture of meat and saliva, so that a part of the enamel surface remains free, and moisten the surface with blood, it will take on a dirty green color if kept at blood temperature in an absolutely moist condition for from twenty-four to forty-eight hours. It is quite possible that the dirty green deposits which form in putrid conditions of the mouth, in stomatitis mercurialis, scorbutica, gangrenosa, etc., or even in inflammatory conditions of less importance, as well as in cases of absolute neglect of the care of the mouth, may owe their green color to the presence of sulfomethemoglobin.' "

Dr. Kirk again quotes from Ziegler's "General Pathology" as follows: "When red corpuscles are just beginning to disintegrate, the coloring matter formed is

hemoglobin; but the yellow and brown granular masses found in cells and lying free in tissues are, as a rule, derivatives of hemoglobin, not hemoglobin itself. These derivatives are divided into two groups, according as they contain iron or not, the former being called hemosiderin, the latter hematoidin." "When acted upon by ammonium sulfid (a derivative of putrefactive decomposition of albumin) hemosiderin becomes black, iron sulfid being formed."

Dr. J. P. Buckley,[1] in discussing the subject of tooth discoloration and its treatment, calls attention to the investigations of Dr. J. E. Hinkins, of Chicago, concerning the chemical composition of human enamel and dentin. These investigations disclosed that iron in combination with aluminum existed in both of these structures, and, furthermore, he states that: "It is not unlikely that future investigation will find that the iron from this source plays a part in the discoloration of tooth structure." Dr. Buckley, moreover, antagonizes the theory that iron sulphid is the cause of the discoloration of tooth structure, and "doubts if this theory can ever be proved to be correct." His objections to the theory of tooth discoloration previously stated are as follows:

"From chemistry we learn that ferrous sulphid is a *black* compound and that no change takes place in the color or otherwise by exposing it to the air. Should the discoloration of tooth structure be due, then, to ferrous sulphid, as claimed by many writers, there would be no necessity, in treating putrescent pulps, so far as preserving the color of the tooth is concerned, for using a remedy which can be hermetically sealed within the tooth. Clinical experience shows that a tooth containing

[1] Johnson's "Textbook of Operative Dentistry."

a recently decomposed pulp, in a large percentage of cases, is not discolored, and that such a tooth will not change in color if the formo-cresol remedy is used in the treatment and always hermetically sealed."

Dr. Buckley furthermore states that: "Neither can the *green* nor *yellow* discolorations of teeth be attributed in any way to the presence of black ferrous sulphid; yet the author is of the opinion that it is possible for this compound to be formed in the ultimate process of pulp decomposition."

Dr. Buckley offers a different theory in explanation of tooth discoloration. He contends that, as the nitrogenous molecule contains a greater amount of *nitrogen* than *sulphur*, 15 per cent. of the former to 0.3 per cent. of the latter, it is most probable that ammonia, a compound of nitrogen and hydrogen, is formed in greater quantity in putrescent conditions than hydrogen sulphid, a compound of hydrogen and sulphur, and that this latter compound did not bear the important relation to discolorations of teeth that has been attributed to it, as previously indicated. The ammonia gas, according to Dr. Buckley, is not only generated in far greater quantity than any other gas in putrescent states, but it has the well known property of uniting with water, forming *ammonium hydroxid*, $NH_3+H_2O=NH_4OH$. Ammonium hydroxid acts upon the soluble ferrous and ferric salts, forming ferrous and ferric hydroxid, $Fe(OH)_2$, $Fe_2(OH)_6$. In this manner, Dr. Buckley reasons, the ferrous hydroxid is formed by the reaction between ammonium hydroxid and the iron liberated from the hemoglobin of the red blood cells. The ferrous hydroxid, a white compound formed as suggested, readily absorbs oxygen, and changes to *ferric hydroxid*, a reddish-brown compound. In this change there is an array of four

colors, white, green, black, and brown, and in the blending of these colors every shade of discolored teeth is exhibited. Dr. Buckley furthermore states that ferrous hydroxid is not the only compound of iron that passes through color changes when moist and exposed to air. This change of color is peculiar to nearly all the iron compounds, but with the possible exception of ferrous carbonate, which could be formed, ferrous hydroxid is the only compound of iron capable of being produced under the stated conditions—viz., pulp putrefaction—the color changes of which correspond to the shades of permanently discolored teeth.

Dr. Buckley states his conclusions as follows: "That the permanent yellow discoloration is due to the formation of ferric hydroxid; the bluish-black discoloration to a mixture of ferric hydroxid and ferrous sulphid, or to a failure of the ferrous hydroxid to become completely oxidized into the ferric form, owing to a lack of moisture or oxygen; the other colors observed are transitory and are due to the gradual transition of the ferrous into the ferric hydroxid. In coming to these conclusions I have accepted the statement that iron plays the most important rôle of all the elements entering into the discoloration problem; for, if it were possible to remove the hemoglobin from the blood or the iron from the hemoglobin, I do not believe the dentin could be discolored by any compound possible to be formed by the process of pulp decomposition."

(3) Therapeutic Applications.—What effects may follow the use of certain applications in a cavity has never been specifically studied. It is well known, however, that the use of some of the essential oils, followed by phenol, may permanently set the coloring matter contained in the oily substance by forming an insoluble

compound. That this method of discoloration may have a wider application than is commonly supposed is probable, and until more extended data is at hand we are unable to entirely eliminate *therapeutic applications* as a possible source of discoloration, or to indicate the various substances formed in this manner that may discolor the tooth, and the methods for its correction.

(4) METALLIC SALTS.—It is now common practice to utilize sulphuric acid in root canal treatment. If steel instruments are employed to carry this acid, the iron salt thus formed is carried into the tooth structure and subsequently discolors it. Hydrogen sulphid present in the dentinal tubes or root canal, originating from the putrefactive decomposition of the contained organic matter, may act upon amalgam fillings, forming salts of the different metallic constituents of the amalgam, by which the tooth structure becomes discolored. Similarly, the tooth may become discolored if the chlorin method of bleaching is adopted, and the chlorin is allowed to act upon gold instruments, or upon a gold filling retained in a cavity. In such cases the tooth assumes the characteristic purplish hue, later becoming black. No doubt the discoloration of the tooth may follow the formation of metallic salts otherwise formed than here indicated, which probability should make the need for caution in all directions duly impressive. As an example of this it may be stated that, whenever an amalgam filling is to be introduced, especially in a devitalized tooth, a lining of zinc oxychlorid, or zinc phosphate, should first be made. Clinical experience teaches that teeth so treated seldom, if ever, discolor as much as those not so treated.

Treatment of Discolorations.—It is evident that the attempt to restore the color of a tooth depends upon

e chemical reaction between two substances, the one nployed to act upon the other present in the tooth tructure, and upon which the discoloration depends. n the previous discussion of the causes of the tooth's liscoloration, the different substances capable of altering the normal color effect of the tooth, and the sources from which these substances originate, were named, and, while it was also determined that we are not in possession of complete knowledge of the subject, nevertheless sufficient data is at hand to indicate that in some instances, at least, the discoloring molecule may be destroyed, and the discolored tooth successfully restored. But to secure such result the manner of the discoloration must be determined, and the reagent utilized that is capable of destroying the color molecule. The former knowledge may be ascertained from the history of the case and an examination of the tooth, after which the best method for restoring the color of the tooth may be selected.

There are two general methods of bleaching teeth, *the oxidation and the reduction method.*

THE OXIDATION METHOD.—This may be subdivided into two classes, *direct* and *indirect.*

Direct Oxidation.—This consists of the use of oxidizing agents from which oxygen may be directly evolved, such as *sodium dioxid* Na_2O_2; *25 per cent. ethereal solution of hydrogen dioxid,* H_2O_2; *alphozone,* $(COOH.\ CH_2.\ CH_2CO)_2\ O_2$; *aluminum chlorid* Al_2Cl_6, and a *three per cent. aqueous solution of hydrogen dioxid;* and *oxalic acid,* $H_2C_2O_4.\ 2H_2O$.[1]

Indirect Oxidation.—This consists of the use of agents from which oxygen may be indirectly obtained. In this method *chlorin* is first liberated, which acts upon

[1] Johnson's "Operative Dentistry."

water, removing its hydrogen to form hydrochloric acid, and liberates the oxygen. Dr. Buckley[1] gives the following agents that may be used for this purpose:

"Aluminum chlorid and a freshly prepared Labarraque's solution (Harlan). Chlorinated lime and dilute acetic acid (Truman). Powdered alum, and Labarraque's solution. Solution of sodium chlorid, electrically decomposed."

THE REDUCTION METHOD.—This consists of the use of agents which are capable of removing oxygen from a chemical substance owing to their readiness to combine with it. The sulphurous acid method introduced by Dr. E. C. Kirk acts upon this principle, and has been found efficient where the discoloration of the tooth has proceeded from the use of certain remedial agents, and in which cases the chlorin methods have been found ineffective. This method, however, as Dr. Kirk says, "is slow in its action and is largely superseded by the dioxid of hydrogen and dioxid of sodium methods." Dr. Kirk describes his method as follows: "100 grains of sodium sulfite and 70 grains of boric acid are separately desiccated and afterward ground together in a warm, dry mortar. The powder is then to be transferred to a tightly stoppered bottle. For bleaching purposes the powder is packed into the root canal and cavity of the tooth, and then moistened with a drop of water, and the cavity immediately closed as tightly as possible with a stopping of gutta percha previously prepared and warmed. A reaction ensues between the boric acid and sodium sulfite whereby sulfurous acid is liberated, thus: $2H_3BO_3+3Na_2SO_3=2Na_3BO_3+3H_2O+3SO_2$."

Dr. Buckley[2] suggests the subsequent washing of the

[1] Johnson's "Operative Dentistry."
[2] *Ibid.*

tooth with an alkaline solution, such as a ten per cent. solution of sodium bicarbonate, or borax, to neutralize the acid.

THE DIRECT OXIDATION METHOD APPLIED.—As previously stated, this method consists of the use of agents from which oxygen may be directly evolved. The "caustic pyrozone," a 25 per cent. ethereal solution of hydrogen dioxid, prepared by McKesson and Robbins of New York, and the sodium dioxid introduced by Dr. E. C. Kirk in 1893, are the two agents of this group which are usually employed in the treatment of discolored teeth. In contact with dead organic matter, the unstable atom of oxygen represented in hydrogen dioxid is quickly liberated and oxidizes the discolored tooth structure, disrupting the color molecule. The tooth to be treated is to have the rubber dam adjusted, after which the canal should be placed in an aseptic state, and the apical end sealed with gutta percha. Any portion of an amalgam or gold filling should be removed. This is particularly indicated if chlorin is evolved in the bleaching process; otherwise metallic salts may be formed which are capable of discoloring the tooth structure. Dr. Kirk next suggests the thorough washing of the tooth with dilute ammonia water, or, better, with a hot solution of borax in distilled water in the proportion of ʒj of borax to ℥j of water. This removes all fatty matter, which, if allowed to remain, prevents the ingress of the liberated oxygen into the dentinal tissue. The cavity and unfilled portion of the canal are now dried, after which the tooth is in proper condition for the application of the pyrozone. It has been a matter of common knowledge with those engaged in bleaching various commercial articles that the bleaching process yields superior results when conducted in an *alkaline* medium, and the clinical

experience of those engaged in bleaching teeth has been corroborative of this. For this purpose Dr. D. N. McQuillen suggests the use of Schreier's kalium-natrium preparation. This is first applied in the pulp chamber and canals and made active by the addition of a drop of distilled water. When the canal has been cleared of the resulting débris by means of appropriate canal instruments, its irrigation with distilled water is omitted, furnishing the desired alkaline medium. The pyrozone may now be applied by means of a platinum probe and the effect noted. If it is found, after continuous applications, that the desired result is not secured, an application of pyrozone upon cotton is seated in the canal for twenty-four hours, after which the additional application of pyrozone usually furnishes satisfactory results. It may be here stated that the 25 per cent. solution of hydrogen dioxid, known as pyrozone, is a powerful caustic; therefore, suitable precautionary measures should be taken for the safety of both patient and operator.

In the use of sodium dioxid the profession has what is now generally regarded as the best means of bleaching teeth. This chemical agent, with a formula represented by Na_2O_2, readily parts with its loosely combined oxygen in the presence of organic matter. The loss of its atom of oxygen converts the sodium dioxid molecule, in the presence of water, into caustic soda, Na_2O. This compound is synergistic to sodium dioxid in its saponifying action upon fatty substances, as well as in its disintegrating effect upon organic tissue, whether normal or in a putrefactive condition. Hence, the organic matter contained in the tubes is removed, and, if the products of putrefactive decomposition are present, these also are removed; at the same time the liberated

atom of oxygen is producing its bleaching effect upon the tooth structure.

As the product is readily decomposed into caustic soda and oxygen, failures have been recorded in the use of sodium dioxid owing to its loss of oxygen. In order to test the efficiency of the product when intended for bleaching purposes, Dr. Buckley recommends the following: "In a clean, dry test tube place about one gm. (15 grains) of the powder and to it add 1 or 2 c. c. (15 or 30 m. of water. If the specimen is good sodium dioxid, enough oxygen should be generated to kindle a glowing splinter held at the mouth of the tube."

Having adjusted the dam upon the tooth to be bleached, the root is filled, as previously indicated, and the preparation applied. Either the dry powder or a saturated solution made by slowly dusting the powder into cooled water may be used. Dr. Buckley[1] thinks that the best results are secured when the dry powder is worked into the canals. This is in accord with the writers' experience. It is well to again emphasize the importance of not using steel instruments in the act of working the powder into the canals, as the evolved oxygen may act upon the steel, forming ferric oxid, defeating the object of the bleaching process. When the powder has been placed in the canals and chamber, a drop of distilled water is allowed to come in contact with it, producing the effect previously noted.

If the discoloration is due to the presence of an iron compound, it is claimed[2] that, by the use of sodium dioxid, ferric hydroxid is converted into ferric oxid, which is an insoluble compound. "If ferrous sulphid is present in the moist state it may be converted into

[1] Johnson's "Operative Dentistry."
[2] *Ibid.*

ferrous sulphate, a soluble salt; but in the presence of caustic soda it would be precipitated as ferrous hydroxid, which, in turn, in the presence of oxygen, is at once reconverted into ferric oxid." If these chemical reactions are correct, therefore, as Dr. Buckley states, the insoluble ferric oxid must be removed mechanically by washing the tooth, which is aided by the formation of caustic soda, and the saponifying effect this has upon the fatty products present in the tubuli. The removal of the soluble soap by washing mechanically aids the removal of the insoluble ferric oxid.

The washing of the tooth may be effected by spraying under pressure warm distilled water into the cavity, drying, and then observing the color of the tooth. If not completely or satisfactorily restored, the bleaching process is repeated. Finally a solution of sulphuric acid (2-10 per cent.) is applied to the cavity for the purpose of neutralizing the caustic alkali, and penetrating the dentin; it may also convert the ferric oxid still present into a soluble sulphate, which can easily be removed by the washing process. When the tooth is dried and the color found to be successfully restored, a lining of *zinc oxychlorid* should be made. This materially aids in preserving the restored color of the tooth. A paste[1] prepared by mixing precipitated calcium phosphate and distilled water has also been recommended for adaptation against the dentin, but does not answer as well for the intended purpose, in the writers' judgment, as the oxychlorid of zinc.

Dr. Harlan's Method.—Originally this was grouped with the chlorin methods, as in the chemical reaction between aluminum chlorid and hydrogen dioxid it was supposed that chlorin was evolved. Further study, how-

[1] Johnson's "Textbook of Operative Dentistry."

ever, showed that the aluminum molecule was not split up, but that the reaction was due to a catalytic action [1] of the aluminum salt, owing to which nascent oxygen is given off from the hydrogen dioxid. This method as presented, therefore, is no better than any other in which hydrogen dioxid is utilized for its bleaching property. More recently [2] a freshly prepared Labarraque's solution has been utilized with aluminum chlorid.

THE INDIRECT OXIDATION METHOD APPLIED.—To Dr. James Truman belongs the credit of introducing the chlorin method of bleaching teeth. Dr. Truman's method, which consists of the use of *chlorinated lime,* commonly called bleaching powder, and *dilute acetic acid* (tartaric or oxalic acid may be used), may also be regarded as the first well-defined effort at the restoration of discolored teeth. In this method chlorin is liberated which, owing to its strong affinity for hydrogen, in the presence of moisture, seizes the hydrogen of water and liberates nascent oxygen. Care should be exercised in the utilization of this method that the chlorinated lime from which the chlorin is to be liberated has not already parted with too much of its chlorin, which readily takes place especially in a moist atmosphere. Chlorinated lime is a dry powder, irritating when held to the nostrils, owing to the presence of chlorin. If it is damp, and fails to impress its irritating quality, it may be regarded as being unfit for bleaching purposes because of the excessive loss of chlorin.

The tooth is prepared as previously indicated, and the powder packed in its interior. Fifty per cent. acetic acid is applied to it, and the exterior sealed with gutta percha. The patient is instructed to return at the ex-

[1] "American Textbook of Operative Dentistry."
[2] Johnson's "Textbook of Operative Dentistry."

piration of one or two days, and, if the color of the tooth is not satisfactorily restored, the process may be repeated. An important desideratum in the use of this method is to avoid the contact of steel, gold, or platinum instruments with the powder, otherwise soluble chlorids may be formed that may permanently discolor the tooth. Wood or bone instruments are usually employed. Dr. Kirk[1] states that several cases of permanent purple discoloration have followed the failure to remove gold fillings from the tooth. When the color has been satisfactorily restored the tooth should be thoroughly irrigated with hot distilled water, dried, and a lining of zinc oxychlorid made, as previously noted.

The Removal of Special Stains.—Permanent discoloration of the tooth may follow the disregard of the effect which the chlorin method of bleaching may have upon gold, present either as a filling, or in the use of gold instruments in applying the bleaching powder to the tooth. A tooth so discolored may pass from the light purplish hue into an almost black shade, the removal of which is exceedingly difficult, if not impossible. A similar final discoloration may follow the use of steel instruments in the utilization of the chlorin method of bleaching, or in the use of sulphuric acid in canal treatment. The treatment recommended in these cases[2] is to rebleach the tooth by the chlorin method. This may have the possible effect of forming soluble chlorids of the metallic stains, which may be removed by irrigating the tooth first with 50 per cent. chlorin water, and later with hot distilled water.

When the discoloration can be traced to silver salts the difficulty of restoring the tooth is not so great. Here

[1] "American Textbook of Operative Dentistry."
[2] *Ibid.*

the chlorin method may be employed, which readily converts the silver stain into a chlorid, which may be removed by means of sodium hyposulphite applied as a bath to the tooth.[1] The difficulty presented in these special forms of discoloration is the determination of the chemical agent, the deposition of which is responsible for the discoloration. The history of the case should be carefully sought as to details. In this manner alone is it possible to arrive at conclusions, which, together with the application of an adequate chemical knowledge, may often lead to very satisfactory results in the effort to restore the color of the tooth.

[1] "American Textbook of Operative Dentistry."

CHAPTER XXIII

THE PLANTATION OF TEETH

Definition.—The plantation of teeth signifies the surgical reëstablishment of the root of a tooth within a socket, either by inserting a human tooth into an existing alveolus from which it may or may not have been removed, or by surgically forming an alveolus into which is placed the root of a tooth.

Classification.—As intimated under the terms of its definition, the operation of tooth plantation may be classified as *replantation, transplantation,* and *implantation.*

Vital Processes Involved.—The accompanying illustrations,[1] prepared from drawings by Dr. H. H. Burchard, theoretically explain the relation of the involved tooth to the alveolus. Fig. 108 illustrates a tooth and its normal attachment and vascular supply. Fig. 109 shows the conditions following replantation. Fig. 110 the conditions following transplantation. Fig. 111 the conditions following implantation. In all cases where one of the forms of tooth plantation is practiced an inflammatory reaction takes place with its attendant migration of the white blood cells and exudation of coagulable lymph. Before the process of repair is well inaugurated many cells die and must be removed. It is for this reason that some writers[2] claim that several

[1] "American Textbook of Operative Dentistry."
[2] *Ibid.*

days at least should elapse before the tooth is placed within the socket, either in replantation or transplantation. But as the insertion of the tooth, at the later period, most likely is again followed by an inflammatory reaction, with its attendant degeneration and death of cells, it appears to be a better plan to immediately replant the tooth after the preliminary methods of pro-

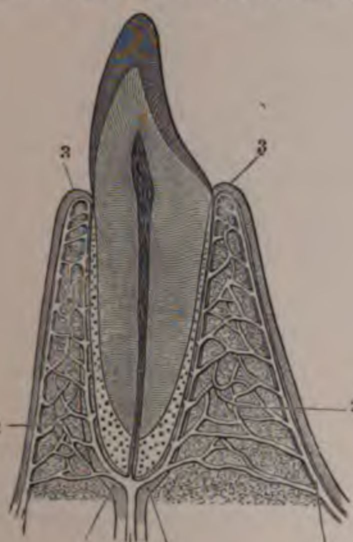

FIG. 108.—A TOOTH AND ITS NORMAL ATTACHMENT AND VASCULAR SUPPLY:

1, 1, apical pericementum in which is seen the main pericemental artery, 5; 2, 2, anastomosing blood vessels; 3, 3, the marginal anastomosing of alveolar and pericemental arteries.

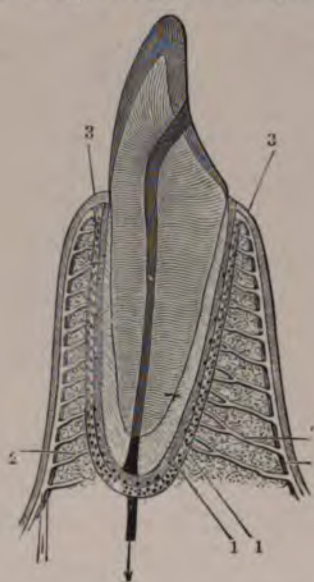

FIG. 109.—CONDITIONS FOLLOWING REPLANTATION:

1, 1, the pericementum and inflammatory effusion between pericementum and alveolar walls; 2, 2, source of blood supply to the area of repair; 3, 3, terminations of alveolar arteries; 5, obliterated arteries.

cedure have been followed. This is the plan recommended by Dr. C. Edmund Kells, Jr.[1]

Considerable discussion has appeared in dental journals as to the process whereby planted teeth become firm. The theory of the revivification of the pericemen-

[1] Johnson's "Textbook of Operative Dentistry."

tum which has been advanced by some writers is untenable. If this theory is made to apply to those cases where teeth are immediately replanted, the proposition is decidedly more tenable. But can such cases be placed within meaning of the theory of revivification? In other words, where a tooth is removed from its alveolus, and immediately replaced, does its pericementum suffer com-

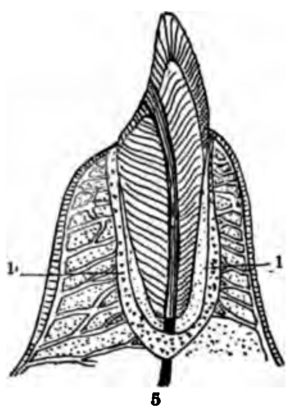

FIG. 110.—CONDITIONS FOLLOWING TRANSPLANTATION:

1, 1, embryonic tissue which will be organized into repair tissue replacing the original pericementum; 5, obliterated apical vessels.

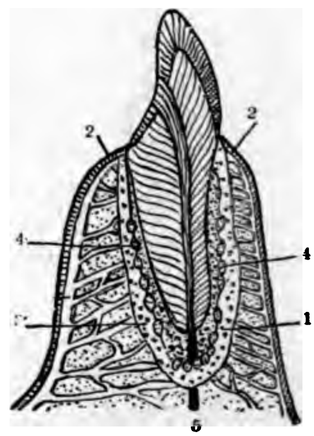

FIG. 111.—CONDITIONS FOLLOWING IMPLANTATION:

1, 1, alveolar arteries; 2, 2, gingival margin; 3, inflammatory still unorganized tissue filling the space between the cementum and walls of artificial alveolus; 4, 4, phagocytes, multinucleated cells attacking cementum of implanted tooth; 5, obliterated apical vessels.

plete necrotic changes? It is more likely that the condition here is one simply of injury, and that under favorable influences repair promptly takes place. This view must also be regarded as being favorable for the immediate placement of the tooth in replantation. The sooner the tooth is returned to its natural surroundings, the less is its pericementum likely to suffer necrotic changes, and, although this tissue resembles periosteum, for which the claim [1] is made that it is capable

[1] Ziegler's "General Pathology."

of maintaining its vitality for some time after separation; this has never been demonstrated, to the writers' knowledge, as being applicable to the pericementum, and does not appear as a reasonable deduction from the histology and anatomy of this membrane.

Dr. Younger, to whom credit is generally accorded for introducing the operation of implantation in 1885, holds to the belief of the revivification of the pericementum of implanted roots. But Dr. Younger cannot satisfactorily explain in what manner this may occur. Others maintain that planted teeth are secured in place owing to the deposition of osseous material in the resorbed areas universally found upon the roots of planted teeth (Fig. 112). According to this theory the planted root induces a degree of irritation in the surrounding walls leading to resorption, and upon the subsequent filling up of the excavations is dependent the success of the operation. Dr. Younger's theory of the revivification of the pericementum of implanted roots cannot be comprehended by any method of logical deduction of the facts of biological processes, and may be safely dismissed. Neither does the second theory, while more commendable than the first, appear sufficiently assuring in the light of deeper analysis. While planted teeth, sooner or later, when removed, show evidence of the resorptive process, also the deposition of osseous material, that these two processes of resorption and deposition should take place, as illustrated in the above diagram, to mechanically secure the tooth in the socket cannot be accepted as the uniform occurrence of so irregular a function as that performed by either the

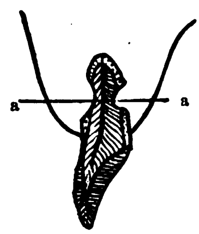

FIG. 112.—IMPLANTED TOOTH:
a, a, excavations due to resorption.

osteoclasts, or osteoblasts, under the conditions here discussed.

Dr. C. Edmund Kells, Jr., who is also committed to this theory of the retention of implanted roots, claims that by means of the X-ray this explanation can be verified, and offers the accompanying skiagraph as evidence that the processes here considered actually take place. The illustration shows a replanted tooth (A) and its neighbors (B B). The pericementum is quite clearly shown about the normal roots, while it appears to be obliterated upon the *replanted root.*

FIG. 113.

This does not appear to the writers as being conclusive evidence for the theory advanced for the retention of *implanted roots.* While little doubt may exist as to the occurrence of resorption and deposition in almost all cases of plantation, great doubt may be expressed that the phenomena of the retention of *replanted teeth* are fully analogous to those of *implanted teeth.* As previously intimated, it is legitimately conceivable that the reparative process is associated with teeth immediately replanted.

Hopewell-Smith has directed attention to the great reparative capacity of the pericementum. But that the repair function of the membrane of the root could in any manner be established in cases of implantation is inconceivable. Furthermore, if the retention of implanted roots was entirely dependent upon the processes of resorption and redeposition, that is to say, if these processes occurred after the manner necessarily implied by this theory, the skiagraph would be capable of an effective verification, as the process of bone

deposition is much slower than the process of resorption.

In what manner, then, can the retention of planted teeth be made to appear more consistent with present physiological and pathological knowledge? In all cases of tooth plantation, as previously indicated, a greater or less degree of inflammatory reaction is excited with its accompanying inflammatory exudate. This exudate is forced against all parts of the root of the planted tooth, and its subsequent coagulation provides the means of firmly holding the tooth in position. That the coagulated effusion, after a period of time, may be removed through phagocytic activity is quite likely, and that resorption of the root also takes place is an established fact. In this manner occurs the subsequent loosening of the tooth. This theory of retention also better explains the observed clinical fact that, generally in those cases of plantation where the pericementum remains intact, more permanent results follow. Here the exudate may diffuse through the membrane surrounding the root, and by the hardening process, which later occurs, a firm hold is secured upon the root. Experiments in planting roots made of ivory, porcelain, and various metals have all ended in failure,[1] which appears as an additional argument in favor of this theory. Such roots being devoid of a membrane do not offer as favorable a means of attachment as the natural root.

Replantation.—This expresses replacement of a tooth into its natural socket from which it has been removed accidentally, or for therapeutic purposes. This operation antedates the others of tooth plantation, and is regarded[2] as having been practiced at a very early date

[1] "American Textbook of Operative Dentistry."
[2] *Ibid.*

of the development of medical knowledge. Where a tooth has been accidentally removed from its socket, in almost all but very aged subjects, its return to its socket, under certain directions, is indicated. Many such cases of replantation have been found to yield eminently satisfactory results, apparently subserving the functions of a normal tooth for many years.

Replantation practiced as a therapeutic expedient in cases of chronic abscess is not as common, at the present time, as formerly. Modern methods of treatment have afforded a larger percentum of cures of these cases, so that the *"dernier ressort"* of extraction and replantation is now seldom found necessary. In those instances, however, in which all efforts toward a cure, including root amputation and removal of necrosed alveolar plates, may be found unavailing, the more radical means of extraction and replantation may be adopted with success.

Procedure.—Until the present time, the first step in the operation of replantation consisted in spraying the mouth with an antiseptic solution, after which the clot was removed from the socket, and when free well swabbed out with cotton and the antiseptic solution. In the recent investigations presented by Dr. G. V. Black in *Items of Interest*, July, 1911, attention is directed to the more favorable results obtained in repair efforts when the parts are not subjected to the irritating effects of antiseptic solutions. These investigations disclose that the use of a *normal saline solution* is followed by the most beneficent effects. In view of these investigations more favorable results may be obtained if the tooth to be replanted is also kept immersed in the salt solution, in place of the various antiseptic solutions usually recommended, the canal having been previously placed in a satisfactory state and the apex closed with

gutta percha. (See chapter on Root Canal Filling.) As the successful outcome of the operation, in a great degree, depends upon the care in avoiding the introduction of septic organisms into the socket, the need for thorough antiseptic precautions is evident. The hands should be cleansed with a soap solution, dried, and later immersed in a 1-1,000 bichlorid bath, rinsed in sterile water, and dried. The instruments employed in preparing the tooth should be in an aseptic state, and later, if the socket is to be deepened for the proper reception of the root, careful attention must be given to the antiseptic requirements. Some operators prefer to cut off the end of the root rather than enlarge the socket. Success has followed either method of procedure, providing the other factors of the operation are favorable. The tooth must be so placed within its socket as to avoid establishing a condition of malocclusion, which, if present, invariably leads to failure.

Transplantation.—This consists of placing within a natural socket a root removed from another socket. The operation was much in vogue prior to the present effective development of dental knowledge, when the operation of transplantation was practiced as a corrective means for numerous conditions, such as diseases of the pulp and pericementum, irregularities, etc. At the present time, as previously stated, the pathological conditions for the correction of which transplantation was formerly practiced are now usually amenable to treatment. This, together with the modern system of crown and bridgework, has rendered almost entirely useless the operation of transplantation.

Implantation.—The operation of implanting a tooth into a surgically formed socket is accredited to Dr. W. J. Younger of San Francisco, the date of his first oper-

ation being June 15, 1885.[1] Similar to many other new modes of practice that have since been introduced, the operation of implantation attracted an enthusiastic following, soon to be lost. In most instances the operation ended in failure, owing to the haphazard methods of the operators, and soon was but rarely performed. Under favorable circumstances, however, implanted roots have rendered service for periods varying from five to fifteen years, in view of which, even at this date, the operation is not without positive support in some quarters. But the immense improvements which have taken place in bridgework, particularly in the last few years, have materially negatived the value of restoring lost teeth by means of implantation, and when to this are added the few instances in which the related factors are favorable for a successful result, it is not difficult to realize that at no very distant day the operation of implantation, similar to transplantation, will cease to have practical application in the restoration of missing teeth.

The argument advanced by those still favorably inclined toward the operation (Dr. Kells in Johnson's "Textbook of Operative Dentistry") is as follows: When one or more single spaces exist in the anterior portion of the arch, restoration by means of a supporting plate is least desirable; and while bridgework is by far more preferable, its utilization does not assure permanent results. Furthermore, as mutilation of the abutment teeth necessarily takes place in this system of restoration, therefore, when failure ensues, the state of the arch, to the extent of the mutilation that has occurred, is not as satisfactory as it would have been without it. Upon this basis the operation of implantation is accorded a

[1] "American Textbook of Operative Dentistry."

definite and justifiable position as a method of restoration. But is the argument regarding bridgework of those favoring the operation of implantation sufficiently strong to clearly conduce to the preference accorded the implantation method of making restorations in the anterior part of the arch? We think not. Modern bridgework applied to the conditions here discussed is capable of effectively restoring the lost tooth (see Bridgework), and the mutilation of the supporting teeth is not of that degree, when intelligently practiced, to be avoided even by conservative practitioners. The writers have a number of central incisor restorations, as well as those in other locations, which have been entirely satisfactory in esthetic and other requirements. These restorations have been doing service for a number of years, and the vitality of the supporting teeth appears to be normally retained. The missing tooth in these cases was replaced by an artificial substitute held in position by means of inlays and short iridio-platinum pins. While favoring this method of replacing lost single teeth, instances may arise where the utilization of the inlay and pin is contraindicated. In these cases implantation may be practiced.

Procedure.—Having decided upon the method of restoration, an impression of the parts and the bite is taken and the plaster models prepared and mounted upon the articulator. In the model a socket is drilled to accommodate the selected root. Having adjusted the root to the socket, an artificial crown is constructed, after one of the well known methods, to meet the requirements of the case, and mounted. The retention cap, which will be described later, may now be constructed. The root with the artificial crown in position is next placed in an antiseptic solution and allowed to remain therein from

a half to one hour. A 25 per cent. solution of borolypto[illegible] or similar antiseptic, well answers the purpose. From this solution it is removed and placed in the normal saline solution, as recommended in discussing the procedure of replantation. All other aseptic requirements, as previously discussed, must here also be effectively carried out.

As the operation of implantation is frequently attended by considerable pain, it is necessary to anesthetize the field of operation. This is best accomplished by the use of either cocain or eucain, and, while the poisonous effect upon the tissues which may follow the injection of either anesthetic, as well as the disastrous effect which this may have upon the successful outcome of the operation, has been frequently noted, nevertheless as the use of a general anesthetic in this operation is regarded as contraindicated, one or the other of the aforementioned agents is utilized. Dr. Louis Ottofy[1] recommends 10-40 minims of a 4 per cent. solution of cocain hydrochlorid. This appears to be an unnecessarily strong solution, and may account for the subsequent destruction of tissue noted by this operator. Equally satisfactory anesthetic results may be obtained with a 1 per cent. solution of the anesthetic, while the poisonous effect upon the tissues may be materially, if not wholly, controlled.

Having anesthetized the tissue to be operated upon, incising the gum is the next step of the operation. This may be done in three ways, each one of which is regarded by some operators as being more satisfactory, although it may be questioned whether any advantage is to be derived from the manner of making the incision (Fig. 114).

[1] "American Textbook of Operative Dentistry."

The three methods of incising the gum are as follows:

1. The X incision.
2. The H incision.
3. The (—) incision.

In the first and second methods of incising the gum more injury to the flaps of the tissue may be inflicted in the subsequent act of drilling the socket. If the third method is adopted there is but one flap to take care of, which is more easily withheld from contact with the reamers in drilling the socket. The concern of most operators for the proper restoration of the gum tissue, as has been pointed out,[1] is almost needless. If the other factors governing the success of the operation assume a favorable aspect, the proper restoration of the gum tissue will most likely take care of itself. This, however, does not imply that care should not be exercised in inflicting a minimum degree of injury to the gum flaps, which course is usually followed by the careful operator.

FIG. 114.—METHODS OF INCISING THE GUM. (Dr. Kells.)

A number of instruments have been devised for drilling the socket (Figs. 115, 116, 117, 118). Those introduced by Dr. Ottolengui admirably answer the purpose. Dr. Kells describes his method of procedure as follows: "A being the tooth to be implanted, three reamers are selected, one of each size of the root at the points marked

[1] Johnson's "Textbook of Operative Dentistry."

B C D. Setting the collar upon the smallest to gage the full depth of the socket, the flap is held away, the parts again sprayed, and the socket quickly drilled to this depth. The gage on the second reamer is set to the point D, and the socket is correspondingly enlarged to this depth. This operation is repeated with the third reamer to the point C. We now have a socket which we are assured is of the required depth and of the shape shown in Fig. 119. Resuming our medium size reamer,

FIG. 115.—OTTOLENGUI'S REAMERS.

FIG. 116.—OTTOFY SPIRAL CRIB KNIFE.

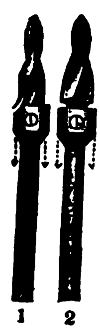

FIG. 117.—ROLLINS SPIRAL KNIVES.

FIG. 118.—YOUNGER-WALKER TREPHINES.

and being careful to maintain our antiseptic precautions, the steps of the cavity are gradually trimmed away, and we find that with few fittings of the root (after each of which it is returned to the antiseptic bath), we have expeditiously accomplished the making of a satisfactory socket."

The socket is then carefully cleared of all débris by directing a spray of the saline solution into it, the root forced into place, and the splint previously constructed cemented, and allowed to remain in position for from four to ten weeks. If the socket drilled into the bone does not exactly correspond to the one prepared in the

plaster model, the artificial crown will not be correctly related with the adjoining or antagonizing teeth. To overcome this difficulty Dr. Kells prepares the root to be implanted with a collar and post which is set with gutta percha (Fig. 120). This is implanted. A clasp band is next fitted to the adjoining tooth, with a projecting arm and tube, the tube exactly engaging the extended portion of the post. When the root has become firm, the post is heated and removed, after which the porcelain crown can be easily adjusted to its proper position. Fig. 121 illustrates the plan suggested by Dr. Kells.

FIG. 119.—(After Dr. Kells.)

Construction of the Splint.—As previously noted, the splint should be constructed previous to placing the root within the socket. No matter what plan of construction is followed, the planted root, or tooth, must be *immovably* held in position for a period varying from two to ten or twelve weeks. This is an important factor in the success of the operation. The form of splint generally favored is that shown in Fig. 122. It is constructed by swaging, or casting, gold to fit the teeth, as shown in the illustration. It covers the occlusal surfaces, and extends about one-half the distance to the gum line


FIG. 120.


FIG. 121.—METHOD OF HOLDING IMPLANTED ROOT BEFORE ATTACHING THE ARTIFICIAL CROWN.

upon the labial or buccal surfaces, and almost to the gum line upon the lingual surfaces, of the teeth. Due regard must be given to the occlusion. In those cases in which the occlusion seriously interferes with the retention of this form of splint, platinum bands may be constructed and cemented in position.

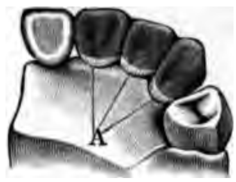

FIG. 122.—MODEL SHOWING RETENTION CAP *in situ*. (Dr. Ottofy.)

Post-operative Treatment.—The after-teatment of planted teeth, as recommended by Dr. Kells, consists in the application of equal parts of the tinctures of iodin and aconite to the gum overlying the planted tooth, as well as to that of the adjoining teeth. It is also necessary to keep the parts free of food débris and other foreign matter. This gradually controls the tenderness of which the patient is likely to complain, and prevents the inauguration of septic processes about the margin, which if allowed to occur would soon lead to failure of the operation. It is also well to see the case daily until the root has firmly reëstablished itself in the socket. In this way the loosening of the splint can be detected without incurring the danger of its complete displacement, which might easily take place if the patient is seen less frequently.

Permanency of the Operation.—The report of most cases of implantations indicates that the majority of the operations fail within two years. On the other hand, in many cases implanted roots have done service for five years, and in a few instances for ten years and more. Where failure occurs within two or three years the operation can scarcely be considered satisfactory. Dr. Kells expresses the view that only those cases which render service for five years or more can be classified as suc-

cessful operations. Failure occurs through resorption of the implanted root, and is regarded as being slowest in progress in replanted teeth, more rapid in transplanted teeth, and most rapid in implanted teeth.[1] No reason is given why this is so, although it must be evident that the observed facts are related to causes and effects, which, though hidden, nevertheless must exist. The writers believe that in the first and second forms of the operation of plantation repair efforts largely assist in the retention of the tooth, and when this takes place the inserted tooth becomes more tolerable, and is, therefore, less like a foreign body, which the cells attempt to remove by the resorptive process. Implanted roots, on the other hand, are incapable of repair, as considered in the preceding form of operations, and are retained by the diffusion of the coagulable lymph through the membrane surrounding the root; and when this effectively occurs, the root may be retained for a number of years; but where this fails to occur, the root becomes a foreign body and is quickly removed by the resorptive process.

[1] "American Textbook of Operative Dentistry."

CHAPTER XXIV

THE EXTRACTION OF TEETH

The claim is often made that teeth are not now removed as frequently as formerly, due to the great advancement that has been made in the knowledge of the various pathological conditions involving them, and in the knowledge of applied therapeusis. While this statement is unquestionably true in regard to the advancement made in dental pathology and therapeutics, the accuracy of the claim that teeth are not, at the present time, removed as frequently as formerly may well be questioned. Abreast with the tremendous strides made in the better comprehension of the pathologic and therapeutic involvement of the teeth, similar, and perhaps greater, advancement has been made in bridgework, establishing the art of replacing lost teeth upon a very acceptable basis; hence, the reluctance and hesitancy formerly existing in relation to the contemplated loss of a tooth in many instances have been greatly lessened, and many teeth are now removed to avoid further annoyance, and because of the highly satisfactory methods of replacing them, and not because all therapeutic expedients have been exhausted, without avail, in their behalf.

Temperamental differences in regard to the ability to endure pain and failure to invest the teeth in the high plane of vital appreciation accorded other organs of the body are also factors of importance influencing the retention and loss of teeth.

In view of this, no unvarying rules can be set down as a guide for the practitioner. It is well, in almost all cases involving the permanent tooth, to impress upon the patient the desirability of following the "method of conservation," but if the related factors argue against conservation the tooth, or root, should be removed.

In a general way it may be stated that extraction is clearly indicated and should be performed in the following circumstances: When the retention of a tooth seriously threatens the patient, owing to septic complications, or to the threatened appearance of a fistulous opening upon the face; when, in cases of chronic septic purulent pericementitis, the discharge involves the nasal chamber, the antrum, or zygomatic fossa; when, in cases of the pathological eruption of the inferior third molar, the necessities of the condition clearly indicate the immediate establishment of space; or in many cases when isolated teeth remain and a denture is to be constructed; or when, as pointed out by Dr. Upson, cerebral and other central nervous disturbances appear to be related with pathological manifestations of teeth and roots.

Extraction of the deciduous teeth is indicated when their retention may cause malposition of the erupting permanent ones, or when the retention of pathologically involved teeth appears to be a factor in an existing physical impairment of the child.

While the extraction of teeth may appear to be a minor surgical operation, its mastery predicates intimate knowledge of dental anatomy and the related sciences, and, in many instances, i. e., those usually classified as difficult cases, its successful performance indicates a technique as skillful as that needed for many major operations.

Anatomical Relations.—The roots of teeth are in-

serted in cavities known as alveoli, formed by the external and internal plates of the alveolar processes of the jaws, and the septa between the two plates. Fig. 123 shows the alveoli of the superior teeth. The form and length of the roots determine the form and length of the alveoli, and when the teeth are lost the alveoli disappear through resorption of the process. Fig. 124 shows the alveoli of permanent teeth—lower jaw. These greatly differ in form from those of the superior arch.

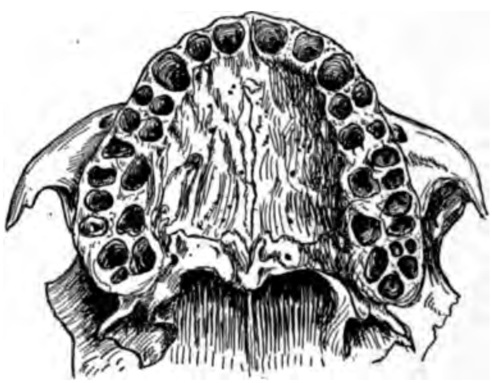

FIG. 123.

The successful removal of teeth can only be attained if the operator has acquired certain requisite knowledge, of which the correct root form of the different teeth constitutes an important part.

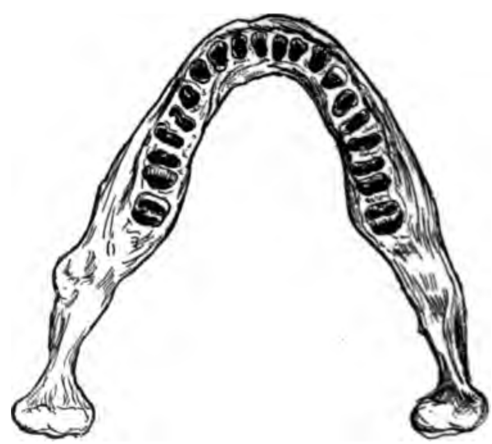

FIG. 124.

The roots of the superior incisor teeth are conical in form, the labial portion forming the arc of a greater circle than the lingual. The mesial and distal aspects of the roots show a somewhat flattened surface, but the antero-posterior diameter is about equal to the labio-lingual, which admits of rotation of the root

within the socket. The central and lateral roots resemble each other quite closely, the central being considerably larger than the lateral. The superior cuspids also have conical roots, each tooth having one root. It is, however, the most prominent root in the jaw, and usually one of the most difficult to remove, owing to its deep attachment. By referring to the previous illustration, it will be noted that the alveolus of the superior cuspid presents a greater outline than that of any other root, and gives to the face the fullness noticeable in the region of the *alæ nasi.* It is for this latter reason that these teeth or their roots are retained in place in many cases when all the other teeth have been lost.

The superior first bicuspid usually has two roots; in many cases it has the appearance of but one root with a bifurcation near the apex, and occasionally the bifurcation is entirely absent. In all cases, however, two canals are present, with a pulpal filament in each canal. The mesio-distal aspect of the roots is considerably smaller than the bucco-lingual, in which respect it is different from the roots previously discussed. It is important to bear this in mind in attempting the removal of this tooth, as will be shown later.

The superior second bicuspid has but one root, the mesio-distal aspect here also being reduced compared to the bucco-lingual.

The superior first molar has three roots, two buccal and one lingual. The lingual is the largest and the posterior buccal the smallest root, and the relation of the roots to each other is characterized by a greater divergence than can be observed in the other superior molar roots, although frequently the buccal roots are fused for quite some distance toward the apex.

The superior second molar also has three roots which

closely resemble those of the first molar, excepting that they are not as prominent nor as divergent.

The superior third molar, like the preceding molars, has three roots, one lingual and two buccal roots. These are still more convergent, as a rule, than those of the second molar, and in many cases the fusion between the roots makes it appear as though the tooth had but one root. In some instances four, and as many as five, roots have been found upon this tooth. The inferior incisors have one root for each tooth, that of the central closely resembling the lateral, excepting that here the condition as to the relative proportions of the two roots is reversed to that existing between the superior central and lateral incisor root. The inferior lateral incisor crown being wider than the central, its root is also larger than that of the central; otherwise its form closely simulates that of the central. The mesio-distal aspect of the inferior incisor roots is much smaller than the labio-lingual.

The root of the inferior cuspid is much smaller than that of the superior cuspid tooth; it is also more flattened in the mesio-distal aspect. In this regard it resembles more the roots of the inferior incisor teeth, although it is larger than the roots of these teeth.

The inferior first bicuspid has a single root, more rounded than that of the inferior cuspid, and easily distinguished from the roots of the superior bicuspid teeth, which, as previously noted, are flattened in the mesio-distal aspect.

The root of the inferior second bicuspid, in general form, closely resembles that of the inferior first bicuspid. It is usually a larger root, compared to that of the first bicuspid, which is in harmony with the larger crown of the second bicuspid.

The inferior molars have two roots, an anterior and a posterior root. The anterior is the longer and more flattened root. The tendency to convergence is as noticeable in the inferior molar roots as it is in the superior molars, and frequently the inferior third molar appears with the roots fused. The variation as to number of roots is here also frequently observed, and at times three very imperfectly developed roots appear upon the crown. Many abnormalities in teeth have been noted. The end of the roots of the inferior third molar may be turned at right angles; this and other forms of abnormalities further emphasize the futility of attempting to formulate definite rules to be literally followed in the extraction of teeth. When the indications, as previously discussed, are present, extraction should be performed, and the operator, with experience, soon acquires that deftness necessary to surmount the obstacles that occasionally are encountered.

But notwithstanding the acquired expertness of the operator in the procedure here under discussion, at times other factors present, which tend toward creating considerable uncertainty as to whether the operation should be proceeded with or suspended. Reference is here made to the conditions of *pregnancy, menstruation,* and *lactation.* Instances are recorded where premature birth followed the operation of extraction. This is especially prone to occurrence during the *third, fourth,* and *fifth months* of pregnancy; hence, in many cases, it is prudent to defer the operation until a later period, when this is not so likely to take place.

Lactation is regarded by some as a strong contraindication against extraction. Not only may the mental excitement of the patient suspend or reduce the quantity of the secretion, but it may also alter its composition.

Dr. T. C. Stellwagen records a case in which an apparently healthy child died after being nursed by its mother, who was in an extremely agitated mental state as a result of an extraction. It is prudent in all cases where, owing to the condition of the patient, complications may arise to confer with the patient's physician. His advice, if followed, might be the means of avoiding dangerous consequences.

In neurasthenic cases the administration of a stimulant one-half hour prior to the operation usually will subserve an excellent purpose, and prevent the almost total nervous collapse that might otherwise follow the extraction. *The valerianate of ammonia* in one-drachm doses has been used with success in these cases. *Validol,* a valerianate of menthol, a more modern preparation, devoid of the disagreeable odor of the first remedy, has also been used with satisfactory results in 5-10 m. doses.

Hemophiliacs present a condition usually regarded as contraindicating extraction. When the indications for the operation, however, exist, and it must be performed, systemic treatment should first be indulged tending to increase the coagulability of the blood, or in accord with any other method made clear after an examination of the patient's blood. Wright[1] has shown that, in some cases, the calcium constituent of the blood is below normal. In no case, however, is it prudent to proceed with the operation, after the tendency to continued bleeding is made known to the operator, without therapeutic aid administered previous to the extraction. Ergot and digitalis are held in high esteem by many. Locally, the best results are obtained, after the tooth has been removed, by closing the socket with borated gauze, placing

[1] *Lancet,* 1902.

a compress upon this, and directing the patient to close down upon it and maintain absolute quietude.

GENERAL PRINCIPLES OF TOOTH EXTRACTION

As no definite rules can be formulated, as previously stated, which can be made to apply to all cases of involved teeth, which shall positively indicate whether extraction is or is not in order, so no unvarying classification can be given as to steps of the preliminary procedure when the operation is about to be performed.

Preliminary Examination.—The first essential preliminary requisite is to make a careful examination of the affected tooth, also to observe whether the adjoining teeth are in position, and, if so, to what extent their presence might interfere with the removal of the involved tooth; next the operator should be assured of the patient's physical condition if an anesthetic is to be used. Unless sufficient reasons exist, it is not wise to make the patient apprehensive by too close questioning. In most cases a few questions, or even a superficial inspection of the patient, is sufficient to assure the operator that *nitrous oxid* may be administered. It is not prudent to appear too deeply concerned about the patient's physical condition. This tends to develop his apprehensiveness concerning the outcome of the operation, and may complicate it. But, on the other hand, the operator should assure himself that no positive contraindications exist to the administration of an anesthetic, or, should he learn of any condition which, while it might not positively contraindicate the use of an anesthetic, might endanger the patient's life if the anesthetic were carelessly administered, he should avoid likely complications by the exercise of adequate carefulness at all stages of the procedure.

Instruments.—The operator having informed himself of the patient's condition, even though an anesthetic is not administered, also of the various relations of the tooth to be removed, as noted, the degree of force and direction of movement likely to be required for the operation, the selection of the instruments which may be necessary for the extraction, may be regarded as the next step in the procedure. It is well to provide for all contingencies; therefore, a greater variety should be conveniently arranged than are likely to be found necessary for the operation.

Dr. J. D. Thomas[1] states that "seven pairs of forceps are all that are required for extraction in ordinary cases." These no doubt will be found adequate for nearly all cases, although different operators may select different forms to meet individual requirements.

Fig. 125 shows the form in general use for the superior anterior teeth. Fig. 126 illustrates the form for the superior molars. Fig. 128 illustrates the Door forceps intended for superior roots. Fig. 129 shows the forceps for the inferior incisors. Fig. 130 illustrates an inferior cuspid and bicuspid forceps, and Fig. 131 illustrates the inferior molar forceps.

The instruments utilized for the operation should be made of material of the best quality, that they may withstand the stress to which they are subjected. Instruments made of an inferior grade of material are likely to fracture under the strain necessary in many instances of extraction. The beaks should be formed thin and sharp, so that they will work down upon the root without injury to the gum tissue, avoiding lancing, which, if performed, tends to develop the fear of the patient. In removing the inferior third molar the gum should

[1] "American Textbook of Operative Dentistry."

Fig. 125

Fig. 126

first be loosened from its attachment to the tooth as a precautionary measure. Cases have been recorded where the mucous membrane and subjacent tissue have been torn to the pharynx in the effort to remove the tooth, the gum tissue not having been previously loosened as suggested.

Position of Operator.—When the preliminary requirements have been satisfactorily attained, and the instruments likely to be required for the operation conveniently arranged in a manner not to attract the notice of the patient, the direct operative procedure is in order. Previous to this, however, the patient's mouth should be thoroughly sprayed with a suitable antiseptic solution, after which the operator selects the suitable instrument for the case, and assumes his proper position for the direct operative procedure.

For Left Superior Teeth.—The advantageous position for the operator in removing a left superior tooth is to the right and back of the patient, the patient's head being held firmly between the left arm and side of the operator; the alveolar process of the tooth to be removed should be firmly pressed upon by the thumb and forefinger of the left hand, which not only aids in holding the patient's head immovably, but also as a guard against injury to the surrounding tissues from mismanagement of the forceps.

For Left Inferior Teeth.—The position of the operator is similar to the foregoing, excepting that he should stand upon a platform, or else the chair should be lowered, whereas in extracting one of the left superior teeth the chair is elevated. Most operators prefer the arrangement of the platform to the raising and lowering of the chair.

For Right Superior Teeth.—The head of the patient

Fig. 127.

Fig. 128.

should be turned somewhat to the left, the operator standing to the right of the patient. The thumb and forefinger are placed in position, as previously indicated, to aid in holding the patient's head, also as a guard against injury to the soft tissues.

For Right Inferior Teeth.—The head of the patient should be turned slightly to the right, the operator standing, as previously stated, preferably upon a platform, so as to be well over the patient. In this position the operator is in the best possible relation to the patient for the removal of any of the right inferior teeth, and with the thumb and forefinger in position as a guard against violent contact of the forceps with any of the remaining teeth, or the soft tissues, the operation is usually most expeditiously performed and without accident.

Lancing.—For reasons previously stated, lancing is now rarely performed as a preliminary step to the operation of extraction. In some cases, however, it is indicated and should be done. These cases are usually roots, the face of which have been partly occluded by an overgrowth of gum tissue. If lancing is not here practiced the gum tissue will be considerably lacerated in the performance of the operation, the infliction of pain will be greater, and the healing process retarded. In these instances it is best to make a linear incision, both labially, or buccally, and lingually, over the root, so that when the beaks of the forceps are forced down upon the root the flap of gum tissue is moved to either side, and the laceration and pain which otherwise are positive incidents of the operation are avoided. Lancing should also be practiced previous to removing either an inferior or superior third molar, to which the gum margin, in many cases, is so firmly attached that painful laceration is

FIG. 129.

FIG. 130.

Fig. 131.

likely to follow the removal of the tooth, unless the margin is first detached. To avoid unduly alarming the patient in making the incisions, it is best to use a local anesthetic. A 1 per cent. solution of cocain pressed upon the gum tissue by means of a pledget of cotton for one minute will be found to answer admirably in most cases.

Technique of the Operation.—The operation of extraction may be divided into three stages:

1. The application of the forceps.
2. The loosening of the tooth.
3. The removal of the tooth.

1. *The Application of the Forceps.*—The beaks of a properly selected forceps will be adaptable to the circumference of the root, and will admit of being forced down upon the root the necessary distance to secure the requisite hold for its loosening without fracture of the root, providing no abnormal condition is present. It has been suggested in some quarters, in applying the forceps, "to push the forceps as if the operator designed to pierce the jaw and have the beaks come out at the top of the head or the under side of the chin." One of the authors, who formerly had charge of the extract-

ing clinics at the Philadelphia Dental College, found after an experience of a number of years that but little good, if any, results from the too forceful attempt to reach the nearest point to the apex of the root. In most cases it is unnecessary for the successful removal of the tooth, and, if the operation is performed without a general anesthetic, but tends to intimidate and alarm the patient.

In those instances where from fracture or caries the tooth structure has been impaired in a manner to interfere with obtaining the requisite hold upon the root, the best plan of procedure is to make the incisions through the gum tissue, as previously noted, force the beaks of the forceps well down upon the root to secure a strong hold upon it, and by crushing through the process, which most likely is already in a state of disintegration, the root may be loosened and removed.

2. *The Loosening of the Tooth.*—The loosening of the pericemental attachment of teeth, in most instances, is accomplished by applying the force in line with the direction of the flattened surfaces of the roots, viz., labio-lingually, or bucco-lingually. For the superior teeth with flattened roots the outward movement is first given, then the inward; for the inferior teeth the inward (preferred by some) is first given, then the outward. This follows the inclination of the different teeth, and when correctly applied prevents fracture, which otherwise is very likely to take place.

The rotary movement may be applied to teeth with rounded roots, such as the superior anterior teeth and the inferior bicuspids, although the superior central incisor is the best example of a rounded root; therefore, the rotary movement is most commonly employed when this tooth is to be removed. The superior lateral may also be loosened by the application of rotation, but where

little space exists between the central and cuspid for turning the tooth upon its axis, the rotary movement should be cautiously applied, and in some instances it will be safer to loosen the tooth with an out and in movement. The superior cuspid root is only loosened after considerable difficulty. The "out and in" movement deliberately applied and then the rotary will usually loosen it.

3. *The Removal of the Tooth.*—When the attachment between the pericementum and alveolar walls has been

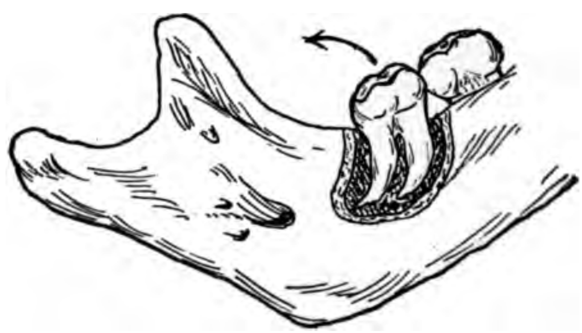

FIG. 132.—UPWARD AND BACKWARD MOVEMENT TO UNLOCK ROOTS.

broken, which in many instances is only accomplished after persistent effort, the tooth may readily be lifted from its socket. In some cases, the most notable of which usually occur in relation to the inferior third molar, after the tooth has been loosened the operator appears to be unable to remove it. This is usually due to the bend at the apical portion of the root, and requires an *upward* and *backward* movement to unlock the tooth (Fig. 132).

The Extraction of the Permanent Teeth. — SUPERIOR CENTRAL INCISORS.—In extracting either superior central incisor the patient is placed in the chair with the head arranged well backward. The proper instrument is then

selected, and, with the left arm about the patient's head and the fingers in position to prevent the lip from interfering with the operation, or being injured in the removal of the tooth, the forcep is carefully but deftly placed in position beneath the gum margin, forced down upon the root, and the rotary effort made to loosen the root. If, after the tooth has been turned to the left and right, it has not been sufficiently loosened to admit of its removal, it should be moved outward and inward, after which it can, as a rule, be easily removed.

Superior Lateral Incisors.—*Left Side.*—The position of the patient is similar to that directed for the central incisors. In most cases a narrow beaked instrument will be required, owing to the narrowness of the tooth, and when the adjoining teeth are in close contact the outward and then inward movements alone should be employed for detaching the root from its alveolar attachment.

Right Side.—When the superior right lateral is to be removed it will be found somewhat more convenient to turn the patient's head slightly toward the left side, otherwise the procedure is similar to that outlined for the left lateral.

Superior Cuspid.—The superior cuspid and superior first molar are generally regarded as being the most difficult teeth to extract.[1] The cuspid because of the size of its root, and the force necessary to break the alveolar attachment; the molar because this tooth has three roots which are usually quite divergent, the loosening of which requires considerable effort, and which

[1] Dr. J. D. Thomas does not regard any one or two teeth as being the most difficult in all cases. He has already found a superior central as difficult as any tooth could be, and a superior first molar as easy to extract as a central usually is.

must be applied to loosen the roots without the accident of fracture.

The position of the patient is similar to that indicated for extracting the incisors. When the right cuspid is to be removed it will be found more convenient to slightly turn the patient's head toward the left side; for the left cuspid the turn should be made toward the right side. The operator's left arm is placed about the patient's head with the fingers holding back the lip, also firmly pressing upon the alveolar process about the root. As previously stated, the forcep should be carefully but deftly placed beneath the gingival margin, forced down upon the root, and the force applied, first outward, then inward. Owing to the bend at the apical end of the root, it is rather hazardous to apply the rotary motion in the attempt made at loosening the root, and which might otherwise be admissible. After the root has been loosened, the apical turn of the root may interfere with its removal, which, however, may be readily accomplished if the root is moved outward and backward.

Superior First Bicuspid.—The superior first bicuspid is regarded by many operators as more likely to lead to fracture in the effort to remove it than any other superior teeth. This is usually due to the impaired state of the crown and of the portion of the roots adjacent to the crown, which interferes with the securement of an adequate hold upon the roots. In many instances, even after a firm hold is secured upon the roots, the divergent position of the bifurcated ends of the roots prevents removal, and in the haste which usually exists to accomplish this the lingual root is fractured. It is far better in the extraction of this tooth to avoid haste, and in deliberately loosening and removing the tooth, also avoiding painful complications. The position of the pa-

tient and movements of the operator are similar to those indicated for the removal of the superior cuspid.

SUPERIOR SECOND BICUSPID.—The foregoing discussion is fully applicable to this tooth, although its removal is not nearly so likely to be attended by complications.

SUPERIOR FIRST MOLAR.—As previously stated, this tooth shares with the superior cuspid, in the estimation of many operators, the position of honor as to difficulty in its extraction. This is due to the firm attachment of its three roots, and to their divergent relation to each other, which exceeds that characteristic of the superior second molar, while in the third molar the roots are usually confluent. In some cases, even after the roots have been thoroughly loosened, considerable difficulty will be experienced in removing the tooth, owing to the greater circumferential measurement of the apical portion of the roots than that found at the cervix. In these cases haste should be avoided, and, after moving the tooth outward and inward, the alveolar walls will finally bend sufficiently that the tooth may be removed without accident. The position of the patient and operator is similar to that discussed for the cuspid and bicuspid.

SUPERIOR SECOND MOLAR.—This tooth is not as difficult to extract as the first molar. The movements for loosening the attachment of the roots, the position of the patient and operator, and the form of instrument employed are similar to those of the first molar.

SUPERIOR THIRD MOLAR.—While the roots of this tooth show a tendency to become confluent, hence materially reducing the difficulties of extraction considered in relation to the first molar, nevertheless, in many cases an excessive number of roots are found, the tooth being found also with roots that curve backward and outward,

and which may be fractured in the removal of the tooth unless adequate care is exercised.

THE INFERIOR ANTERIOR TEETH.—As the roots of these teeth are similar in form, one discussion concerning their removal is applicable to all. The operator assumes a position posterior to the patient, and preferably elevated, by standing upon a platform. The thumb of the left hand is placed upon the inner alveolar plate, while with the remaining fingers the lower lip is held away, and aid also rendered toward sustaining the immovable position of the head. The proper form of instrument is selected, carefully adapted to the root, and by forcing the tooth *first outward, then inward* [1] the root is finally loosened, after which the tooth is easily removed. The inferior cuspid is more firmly attached than any of the incisor teeth; therefore a wider beaked instrument than that indicated for the incisors should be used, and more force will usually be required to loosen it.

THE INFERIOR BICUSPIDS.—The left inferior bicuspids are governed by factors similar to those previously discussed in relation to the inferior cuspid. In extracting the right inferior bicuspids the position of the operator is entirely different. The patient's head is sustained in a forward position, the operator standing to the right and *anterior to the patient.* The thumb and forefinger of the left hand are placed over the process of the tooth, the lip and cheek held safely back, the instrument carefully applied, and with the *out and in* movement the tooth is loosened, and finally lifted from its socket.

INFERIOR FIRST MOLAR.—Some writers [2] regard this as the most difficult tooth to extract when all the other

[1] Some extractors prefer giving the inward movement first to follow the inward inclination of the lower teeth.

[2] "American Textbook of Operative Dentistry."

teeth are in position. The authors' experience is not in accord with this, although considerable difficulty is frequently encountered in the removal of this tooth—the right inferior first molar being usually more difficult to extract, owing to its position, than the left. For the left molar the position is the same as for the left inferior bicuspids, while for the right molar the position is also similar to that assumed for the right bicuspids. The outward and inward movements are given the roots, excepting when the operator may prefer to give that movement first that would correspond to the inclination of the crown, which is usually the inward.

Inferior Second Molars.—This tooth is not as difficult to remove as the first molar, the roots not being as divergent. The outward and inward movement is indicated, and the position of operator and patient is similar to that discussed for the inferior first molar.

Inferior Third Molars.—This tooth is readily loosened and removed if no complications exist. These are usually found in relation to the curvature at the end of the roots. The movements whereby the roots, as a rule, are readily loosened are the outward, upward, and backward. If these fail to unloosen the roots, a safer plan is to have a skiagraph prepared which definitely indicates the form and location of the roots, after which it is not a difficult matter to dissect the overlying gum tissue, and by means of a bur, carried in the engine, the outer alveolar plate is cut away and the tooth removed.

TREATMENT FOLLOWING EXTRACTION

After the tooth has been removed the patient will usually complain of more or less pain, which in most cases disappears after a short period of time, unless the force necessary to loosen the tooth has so severely

strained the alveolar walls as to inaugurate an al[illegible]litis, in which case the pain becomes intense and m[illegible] persist for days. This condition also occasionally f[illegible]lows the removal of a hypercementosed root, and, i[illegible] many instances, will only yield to an injection of [illegible] solution of cocain. Furthermore, the gum tissue is likely to be lacerated, and sharp edges of the process may also be present. The removal of the lacerated portion of the gum tissue and the sharp pieces of bone is indicated, and will hasten the recovery of the parts, whereas, if allowed to remain, the patient is thereby subjected to considerable suffering, as the forcible contact of the injured gum tissue against the spicula of bone is exceedingly painful. The use of the curved scissors and a carborundum stone in the engine will quickly remove the torn portion of gum tissue and sharp edges of bone.

If no other complication, such as hemorrhage, presents, the question as to the treatment of the socket from which the tooth has been removed should be considered. In most cases, beyond the application of a pledget of cotton saturated with phenol sodique, or camphophenique, or some antiseptic combination, the socket receives no further treatment, and still healing ensues. The experience of most operators will verify this. Considering the multitudes of pathogenic bacteria abounding in the oral cavity at almost all times, the infrequency of infective complications in the face of apparent neglect can only be accounted for upon the basis of the existence of *protective influences,* which very likely originate, not from one, but several, sources.

If, however, the alveolar walls have already suffered from the effects of an infective process, for which the tooth has been removed, a safer plan to follow, until the process of healing is well completed, is to pack the

socket with borated gauze, the oral cavity being treated antiseptically, and not risk serious complications by chancing the existence of *protective influences,* which, while they might protect the socket against septic organisms, providing the alveolar process was not already the seat of septic processes due to the septic state of the end of the root, might be incompetent to provide immunity for the socket under the altered condition originating from the septic root.

Hemorrhage.—The bleeding which persists for a short time after extraction is usually not heeded, and no effort need be made to arrest it, as it may aid toward early relief from pain by reducing the pressure in the surrounding tissues. But if after the lapse of several hours the flow still continues, or if secondary hemorrhage occurs, therapeutic aid is indicated. If the mouth is examined at this stage, usually a large mass of clotted blood will be found overhanging the socket, with an oozing of blood from its edges. This clot should be removed with a pair of pliers, the clot in the socket usually coming away with it. The socket may now be sprayed with a mild antiseptic solution, a small pledget of cotton carrying two or three drops of a mild adrenalin solution is next placed down in the socket, the remaining portion of the socket is packed with sterilized cotton, and upon this an additional quantity of cotton is placed, as a compress; the patient is then instructed to bite down upon this and remain quiescent. In place of the adrenalin solution tannic acid and other astringents have been used with success. If this treatment is followed internal medication will be found unnecessary. In an experience extending over many years the authors have yet to see a case of hemorrhage following extraction which did not respond to this method of treatment.

The treatment of hemophilia has already been discussed.

Accidents.—Under this heading may be discussed *the fracture of the crown or root, fracture of the alveolar process, fracture of the jaws, dislocation of the lower jaw, the entrance into the pharynx or larynx of the extracted tooth or root, syncope.*

THE FRACTURE OF THE CROWN OR ROOT.—This most commonly arises from undue haste in the effort to extract the tooth. The necessity for first loosening the root, prior to the attempt made to remove it, has been previously discussed, but some operators confound *quickness* with *expertness,* and in the desire to extract the tooth quickly it is not thoroughly loosened, and the risk of fracture is incurred in the subsequent effort to remove it; or, in the existent haste to extract the tooth, undue force is applied and its fracture follows. In some few instances the fracture is unavoidable, owing to the impaired state of the root. In these cases it is best to administer nitrous oxid, and by forcing the forceps down upon the root and crushing through the process, the accident of fracture is likely to be avoided.

FRACTURE OF THE ALVEOLAR PROCESS.—Where, as in the preceding instance, the instrument is forced down upon the root to engage its resistant portion, fracture of a small piece of the process inevitably follows. This, however, is to be differentiated from the more extended fracture that may follow the undue or incorrect application of force, and which, when it occurs, may seriously injure the adjoining teeth. Special care in extracting is to be observed in the removal of a tooth or root situated in close proximity to the adjoining teeth.

FRACTURE OF THE JAWS.—With the improved forms of instruments now at our command fracture of the jaw is entirely avoidable, and cannot take place unless the

bone is in an abnormal state from previous fracture or disease; or the fracture may follow at any time the sudden application of undue force in the desire to quickly perform the operation.

Dislocation of the Lower Jaw.—If the ligaments sustaining the temporo-mandibular articulation have been loosened, dislocation of the lower jaw may follow the attempt to extract a tooth. In such instances the application of severe force should be avoided.

The Entrance into the Pharynx, or Larynx, of the Extracted Tooth or Root.—The possibility of serious complications following the escape of the tooth or root should ever be before the operator, and some provision made prior to the operation by conveniently arranging instruments that, in case of such an occurrence, valuable time should not be lost in first looking for a suitable instrument with which the escaped tooth might be removed. The pharyngeal forceps should always be at hand. Furthermore, in realizing the seriousness of a tooth entering the larynx, adequate care is to be exercised to guard against the accident, which is the surest method of avoiding it.

Syncope.—This frequently follows the operation of extraction, and is noted more commonly in women than men. As a rule, the attack is successfully treated by placing the patient in a horizontal position and elevating the feet, thus inducing the blood to flow to the heart and brain. The administration of 30-60 m. of whiskey, brandy, or aromatic spirits of ammonia will promptly restore the patient. In more serious cases, which may occur where cardiac disease is present, the hypodermic injection of strychnin sulph., 1/60-1/30 of a grain, or other cardiac restorative may be indicated.

Other Accidents.—Besides the foregoing accidents,

cases are recorded where, in the effort to extract a tooth or root, it was forced into the *antrum,* with which cavity the root communicated. Such an accident is exceedingly improbable; however, should it take place, the tooth or root can easily be removed with the pharyngeal forceps.

The fracture of the maxillary tuberosity in the removal of a superior third molar has also been recorded, followed by severe hemorrhage, owing to the rupture of the posterior dental artery. While it is only in rare instances that this or the foregoing accident is likely to complicate the operation of extraction, it is at all times the safest plan to invest the procedure with adequate care that all danger may be avoided.

EXTRACTION UNDER GENERAL AND LOCAL ANESTHESIA

Very few cases of extraction are now performed without first rendering the individual either unconscious or else desensitizing the tissues about the root to be removed, that the operation may be conducted without the infliction of pain.

The present almost universal practice of utilizing either one or the other method is in a very large measure due to the safety with which nitrous oxid has been administered for many years to hundreds of thousands of individuals, and, while its inhalation to the point of loss of consciousness is not entirely without danger, it is almost so with this agent; otherwise its use in so many cases in the past, and frequently by administrators who understood but little of its physiological action, would not have been almost entirely free from loss of life. It is obvious that under normal conditions the use of an agent, even as unattended by danger as is

nitrous oxid, nevertheless, in its ability to establish the state of unconsciousness, indicates an action upon the nerve centers menacing to life, and many individuals appear to realize in this action a dangerous property possessed by the agent, and which might easily carry them into an eternal unconsciousness. While there can be no argument as to the element of danger existing in relation to any agent capable of inducing the state of unconsciousness, nevertheless, in relation to nitrous oxid, the danger of carrying the individual beyond the anesthetic state and overwhelming the vital centers in the medulla is reduced to the minimum, if not entirely eliminated. This is due to the paralytic effect upon the muscles of the epiglottis which follows almost immediately upon the induction of the anesthetic state when the patient is allowed to inhale more of the agent than is required for the anesthetic state, and which prevents further inhalation of the agent by the closure of the glottis; and while respiration ceases with the closure of the glottis, which is at all times a dangerous sign, under the condition here discussed it may almost immediately be induced by traction upon the tongue. Therefore, in the use of nitrous oxid it is quite difficult to overwhelm the vital centers in the medulla, as can easily be accomplished in the use of ether or chloroform.

The two objections frequently brought forward against nitrous oxid deal with the *shortness of the anesthetic state,* which usually persists from 30 to 45 seconds, *and the asphyxia which follows its inhalation.* As to the first, the shortness of the anesthetic state, at the present time this can scarcely be sustained as an objection in relation to extraction. Formerly, when it was a common occurrence to remove four, five, and more teeth at one time, frequently the patient returned to conscious-

ness before the removal of the last tooth; hence the shortness of the anesthetic state of this agent was urged as an objection against its use. At the present time we scarcely, if ever, find it necessary to remove so large a number of teeth, or roots, at one sitting; therefore, the shortness of the anesthetic state can seldom be made to apply.

The second objection commonly urged against the use of nitrous oxid, viz., *the production of asphyxia,* has likewise been rendered quite inapplicable, owing to the admixture of oxygen with the gas by means of the special apparatus introduced by Dr. Hewitt of London, or according to the simpler method advocated by Dr. J. D. Thomas of Philadelphia.

The apparatus shown in Fig. 133 is made by the S. S. White Co. The amount of oxygen required to obviate the asphyxial symptoms present when nitrous oxid is given alone may vary from about 2 to 5 per cent.; the operator, closely observing the patient, guards against the cyanosis of the lips by admitting additional oxygen. In the use of the special apparatus the induction of the anesthetic state is somewhat delayed, two minutes being about the average time necessary to anesthetize the patient, while the anesthetic state may be prolonged to about two or three minutes, if so desired.

In Dr. Thomas's method the hood face-piece is discarded. In its place is used the inhaler introduced by Dr. Thomas and shown in the accompanying illustration (Fig. 134). It is "made of vulcanized rubber turned to the proper dimension and filled with valves made of rubber dam. These valves have the property of fitting closely, making the passages air-tight, and being flexible they admit the gas to the lungs with little or no obstruction." In administering the gas Dr. Thomas

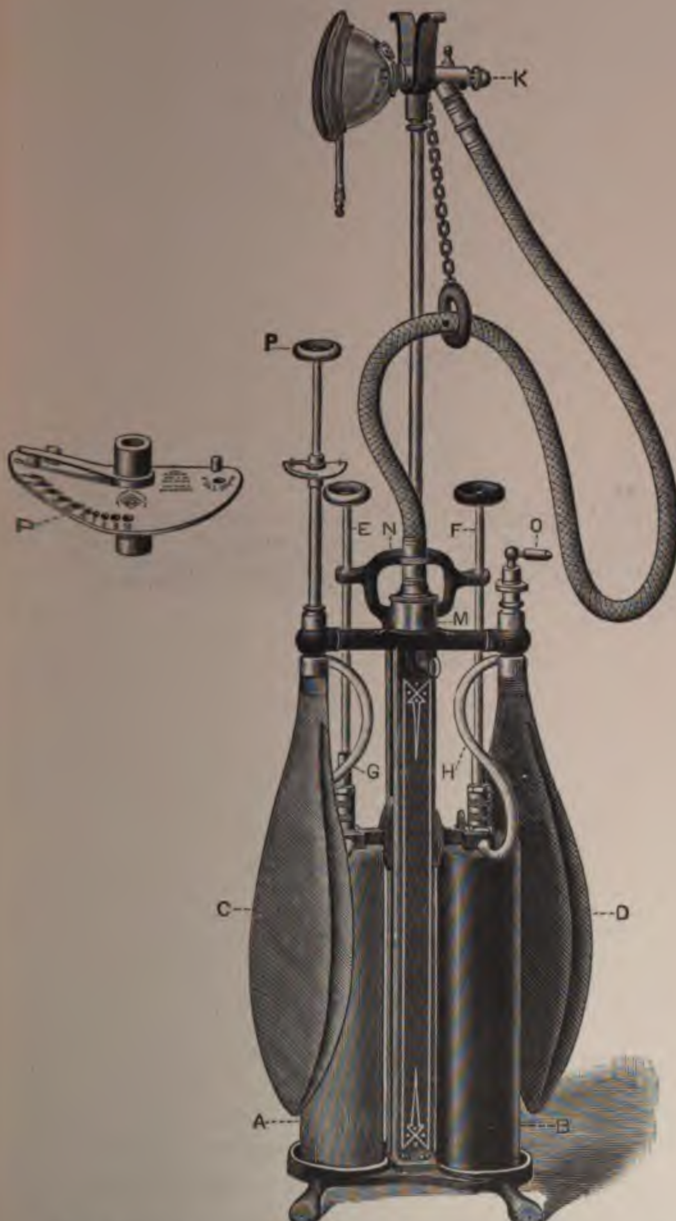

FIG. 133.—APPARATUS FOR COMBINING NITROUS OXID AND OXYGEN.

controls the nostrils and lip with the fingers of the left hand, and the lower lip with the fingers of the right hand, so as to admit oxygen at the proper time, thereby almost entirely eliminating the asphyxial symptoms present when oxygen is excluded. Those who have witnessed the successful exhibitions of this method regard

FIG. 134.—THOMAS'S INHALER.

the Hewitt or any special apparatus as unnecessary, excepting where a prolonged anesthesia of several minutes is desired.

Dr. Thomas directs his patients to breathe as in ordinary respiration to obtain the best results, without the exertion noted when long and deep breaths are taken, or the sense of suffocation experienced when breathing slowly and less deeply. In either case complications are likely to ensue, whereas, if the instruction to breathe normally is carried out, and a certain amount of oxygen admixed with the gas by controlling the nostrils and lips as advocated by Dr. Thomas, perfect anesthesia is induced, without the cyanosis of the lips and the convulsive muscular action present when the gas is admin-

istered without oxygen. Notwithstanding the absolute safety of nitrous oxid, and the elimination of complications when administered as previously advocated, new anesthetic combinations are introduced, from time to time, for which the most extravagant claims are made in the hope of creating a demand for them. Not one of these combinations has yet demonstrated the worth of nitrous oxid, while some are exceedingly dangerous and should never be administered.

Extraction Under Local Anesthesia.—The unwillingness frequently manifested by patients to lose consciousness, also to submit to the operation of extraction without the assurance that no pain will be experienced, together with the unpleasant effects often noted when nitrous oxid is administered in a pure state, i. e., without oxygen, induced many operators to utilize substances applied locally, as a spray, and which, owing to their volatility, rapidly evaporated, resulting in a refrigeration of the tissues, in which state teeth can be extracted without pain, and later, the hypodermic injection of substances possessing anesthetic properties, which rapidly superseded the volatile substances earlier in use.

While, as previously stated, teeth can be extracted without pain consequent upon the refrigeration of the tissues, which state can easily be induced by directing a spray of ethyl chlorid over the root of the tooth to be extracted. But both operators and patients soon learned that, in most cases, the pain occurring as the tissues again assumed a sensitive state was more enervating than the thought of the loss of consciousness under nitrous oxid, and, as in many instances the use of the various refrigerants was followed by necrosis of the tissues to which the application was made, and furthermore, with the introduction of cocain, which opened a

new field of wonderful possibilities in desensitizing a circumscribed area of tissue, the utilization of the former means of obtaining analgesia of the tissues surrounding the root was abandoned.

At the present time ethyl chlorid as a spray is occasionally utilized by some operators. The gum tissue adjacent to the tooth to be removed is protected by means of napkins, and the spray of ethyl chlorid directed against the exposed tissue, which soon assumes a *whiteness,* when the tooth is to be extracted. The too rapid return of the tissues to a normal state may be prevented by holding a piece of ice against the tissue, and much of the pain commonly noted with this method is avoided.

As previously stated, with the introduction of cocain all other means for obtaining a desensitized local area were soon displaced, and the drug quickly claimed an enthusiastic following among operators that perhaps has never been equaled by any drug used in dentistry. It did not take a great period of time, however, to demonstrate convincingly that cocain is a poisonous alkaloid, and the many instances of cardiac and respiratory failure that followed its hypodermic use induced many to abandon it entirely, and others to adopt a more cautious use of the agent.

It was determined that the stimulation of the heart and respiration in most cases was soon followed by depression; that in some cases the depression of these functions did not occur until one hour or more after the injection of the drug; that many persons, especially women, evince an idiosyncratic behavior toward the drug; that in some cases the toxic effects were shortly followed by death.

Among other things it was also determined that so-

lutions of cocain which had been prepared for some time were especially prone to develop toxic effects.

The synthetic preparation known as *eucain* was next introduced as a local anesthetic, which property was predetermined because of the chemical similarity of this drug with cocain. The claims usually made for *eucain* are, that it is less poisonous than cocain, that its solutions are chemically more stable, and admit of boiling to effect sterilization, without the splitting up of the agent, as is the case with cocain when subjected to heat. But while these claims are allowable, it was also soon determined that the anesthetic effect following its use is not as deep as that produced by cocain, and that a degree of toxicity is exhibited in many cases in which the agent is used.

In view of the reports gathered from many sources, the safest agent at our command at the present time for the extraction of teeth is nitrous oxid, and, when utilized in combination with oxygen, either according to the Hewitt or Thomas method, it represents the best method for the elimination of pain for the operation of extraction, and at the same time safeguards the patient from dangerous complications, which frequently manifest themselves in the utilization of any of the other methods now before the profession.

SECTION II

PROSTHODONTIA

CHAPTER XXV

THE STUDY OF THE MOUTH PRIOR TO TAKING THE IMPRESSION, SELECTING THE BASE AND FORM OF DENTURE

The necessity for a careful study of the conditions prevailing in the mouth prior to taking the impression is obvious when the importance of the functions of the plate to be inserted is recognized. In proportion as mastication is impaired, or the normal facial lines are lost, in that degree must be measured the importance of the plate; and as the success attained in restoring the impaired mastication, or the lost facial lines, through insertion of the plate, primarily depends upon a satisfactory state of the mouth, the study of the oral cavity in its *pathologic* and *physiologic aspects* is a necessary preliminary to taking the impression.

Pathologic Aspects.—The reader is referred to the chapter on Oral Hygiene for a consideration of the various pathological manifestations of the soft tissue of the mouth. It is almost needless to add, so well is it generally comprehended, that any departure of the oral mucous membrane from the normal state must be corrected. An existing stomatitis must be eradicated before any attempt is made to construct the denture, and if this is etiologically associated with a systemic state, the patient should receive medical attention at the hands of a physician. Unless this is done the success of the prosthetic effort is seriously compromised. In those cases where several teeth remain in the arch, these

should receive all necessary treatment to place them in a healthy state. All foreign deposits should be removed, and, if these are accompanied by a marginal gingivitis, this likewise must receive adequate treatment for its correction. If a pyorrheal involvement of any tooth is detected, no matter how slight it may appear to be, every effort should be directed for its complete elimination, and the alveolar structures and gum margin placed in a condition of health before proceeding with the construction of the denture. Failure to comply with these preliminary requirements will often jeopardize the success of the subsequent efforts, irrespective of the skill displayed in constructing the denture. This cannot be made too emphatic, as too frequently the attempt is made to proceed with the following constructive processes of the plate, while the mucous membrane, and the remaining teeth, plainly indicate pathological states the continuance of which must react unfavorably for the success of the operation. This neglect ofttimes is invited because only the mechanical factors of the prosthetic effort are considered, to the entire disregard of the vital factors, upon which, as previously stated, much of the success of the plate depends. Elsewhere it has been expressed that at no time should the vital aspects of the teeth and the surrounding tissue be completely subordinated to the desire to construct a mechanically perfect piece of work, and, while at times sacrifice in this regard is necessary, the vital considerations applicable to every dental operation should never be entirely disassociated from the mechanical.

Physiological Aspects.—It is generally recognized that only in a few instances can be found conditions approaching the ideal for plate work. Aside from the form of the arch, which is not within present considera-

tion, the entire oral mucous surface is exposed to such a variety of irritants that rarely do we find an instance where a normal condition obtains. As the necessity for the insertion of a plate usually appears when patients approach or have passed the fiftieth year of their age, it may readily be recognized, in view of the long-continued action of many factors tending to subvert the normal state of the oral mucous membrane, that its abnormal state sooner or later must be established.

The markedly changing temperatures of food preparations, digestive disturbances, smoking, disease, the action of drugs, oral septic conditions, etc., finally tend to destroy the physiological aspect of the oral mucous membrane. But within certain limits the affecfed mucous surface offers no serious obstacles to the successful adaptation of a plate. This may be observed, for example, in the case of the smoker, with a slightly hyperemic mucous surface which cannot be reduced, and to which a plate may successfully be adapted. The physiologic oral mucous membrane may be viewed as a light pinkish surface, neither dry nor of the "weeping" variety, and presenting no special pathological indications to menace the insertion of a plate. When the safe limits of physiological departure have been passed, corrective measures must be employed, otherwise the mechanical effort will most likely end in failure. It is quite clear that the physiological aspect of the teeth remaining in the arch is equally important in relation to the success of the denture as that of the oral mucous membrane, and while, in some instances, a remaining tooth may have lost a portion of its alveolar wall, still such teeth may be retained and subserve a useful purpose for many years. But all calcareous deposits must be removed, septic conditions about the gum margin or at the apical

end must be thoroughly eradicated, and the tooth placed within safe physiological environment, before proceeding with the construction of the plate.

Retention of Natural Teeth.—The foregoing considerations obviously include those which determine the retention or extraction of remaining natural teeth. If every effort is to be directed for the establishment of a healthy oral state, it is evident that only such roots or teeth as are intended for retention would come within the province of the therapeutic efforts. But in some instances a number of teeth might be present in the arch that do not require the aid previously referred to, and a decision must be made whether one or more of these are to be retained or extracted. This necessarily will depend upon their aid or interference with the proper retention in position of the plate, or their interference with an esthetic arrangement of the artificial teeth In those cases where the form of the arch, and the texture of the overlying gum tissue, are favorable for the retention of the denture, the need for conserving one or more of the natural teeth is not as great as it is in those cases where excessive resorption has occurred, or where other conditions obtain arguing against an unaided retention of the plate. Here the retention of an additional root or tooth might be of the utmost importance for the future comfort of the patient. In cases presenting malposed teeth a like necessity exists for careful consideration as to the expediency of extraction or retention. The excessive trimming of the plate in the region of divergent teeth, for example, might easily be the means of preventing a successful retention. But this must not be construed as an invariable recommendation to remove malposed teeth. In many cases the operator may possess sufficient skill to secure the

desired adaptation of the plate without extraction, and every effort should be put forth to test one's capacity in this relation, in order that the tooth might be retained in the arch, especially if its retention is likely to be a factor in the better retention of the plate.

Whenever possible the cuspid roots are retained. This is desirable, owing to the inability to completely restore the fullness which they give the facial lines. This has been indicated in the chapter on Extraction. The absence of the cuspid roots is readily detectable, owing to the depression visible in the region of the canine eminence; therefore, for esthetic reasons, this should be avoided.

Isolated teeth are seldom retained. Cases may arise, however, where a solitary tooth may subserve a useful purpose in aiding the retention of a plate, which otherwise might prove to be exceedingly troublesome; and while it may be argued that the retention of a solitary tooth is likely to be of short duration, nevertheless it is advisable to do so under conditions previously indicated. After the patient has become tolerant of the presence of the plate, the subsequent loss of the tooth is likely to be followed by less inconvenience than would have been experienced if the tooth had been removed prior to the more tolerant state of the patient.

The retention of a solitary tooth in the lower arch is frequently a matter of still greater importance. The difficulty of maintaining a lower denture in place increases in proportion to the absence of a deep ridge; and if an attachment can be made but to a solitary tooth, the discomfort of the patient may be materially lessened. For this purpose the incisors are least serviceable, and a clasp attached to an inferior incisor is not likely to prove an effective aid in supporting a denture. A

better plan, in these instances, would be to remove the crown of the incisor, fit a cap and tube to the root, and attach a "split post" to the plate. (See Removable Bridgework.) Incisor roots prepared after this manner in a number of instances have rendered important service in supporting the plate in position.

Incomplete as is the foregoing discussion concerning the advisability of extracting or conserving one or more roots or teeth, it should be sufficient to indicate the careful consideration that should be given to every case preliminary to the procedure of taking the impression and constructing the plate. It is impossible to formulate invariable rules for the guidance of the operator. Each case will be found to differ in some aspects from the one preceding it, and should receive the most thoughtful consideration within the power of the dentist to bestow, in order that the best results might be obtained in the finished piece.

Related Factors.—When extraction has been practiced the query naturally follows as to the length of time that should elapse before proceeding with the impression. This will depend upon the number of teeth extracted, and the conditions developing after the removal has been effected. At times the removal of a single tooth is followed by such acute reaction in the tissues surrounding the root that several weeks may elapse before the parts have healed sufficiently to allow of the taking of the impression. This may occur in the removal of a hypercementosed root, in which cases the severest reactions usually take place. In other instances a severe infection of the soft tissue may follow the extraction; and if an impression is taken before the swelling has been reduced, an ill-fitting denture will be the re-

sult. It may be in place here to state that severe infection of the gum tissue is likely to follow the hypodermic use of cocain solutions, especially if the strength of the solution exceeds 1 per cent. It is never advisable to use the anesthetic for this purpose in greater concentration if complications are to be avoided.

While the extensive extractions formerly so frequently practiced are now almost unknown, cases may present where several teeth require removal, and where material aid may be rendered toward healing by the exercise of a few simple acts. These are related to the removal of pieces of the alveolar plates, which otherwise are removed by the resorptive process, and which prior to removal are exceedingly irritating to the soft tissue, and which, if allowed to be removed by the slower process, necessarily delay the following steps. In some instances it is a good plan to insert a temporary denture in order to avoid excessive resorption of the alveolar tissue, which, if it occurs, would be unfavorable for the best service of the permanent plate.

Selection of Base.—In the study of the oral cavity preliminary to taking the impression the base best adapted for the case should be decided upon. Gold is generally regarded as being of first choice. The oral tissues are more tolerant of its presence than of vulcanite, and the only rival it may be said to have is continuous-gum, providing that the weight of either the gold or continuous-gum set, in full cases, does not contraindicate the use of either. This applies to full upper cases only. In the inferior arch weight is desirable, as it tends to keep the denture in position. The better tolerance of the oral tissues for a metallic base is frequently seen in the hyperemic state of the mucous surface when vulcanite is utilized as the base. This has

been explained[1] as being due to the reduced conductivity of vulcanite. To what extent this conforms to the facts has never been scientifically determined, but it is claimed[2] that a plate constructed of a good conductor does not produce the irritating effect so frequently observable under vulcanite. How much of the irritation may be due to the lack of a proper polish of the plate, and to the collection of septic agents in the unpolished and uneven surface of the plate, cannot be estimated. The fact that the hyperemia has been observed where cleanliness has been maintained, and where the denture has been satisfactorily finished, apparently supports the view that the cause is associated with an insufficient conductivity of the base. It is claimed[3] that vulcanite "serves best in mouths having firm gum tissue, a high vault, and where the bulk of the piece is unusually great." The importance of the impression, however, cannot be overestimated, and it may be questioned whether any of the materials usually utilized for the base may not be satisfactorily adapted if a suitable impression has been secured, and if the subsequent steps of the procedure are made to conform to the necessities of the case. The direct conformation of vulcanite to the cast is in its favor, while in the swaged base the intervening steps necessary before the metal is made to conform to the lines of the arch multiply the opportunity for inexactness. The devices which have been introduced for swaging the plate directly to the cast have been successful only in a small percentum of cases; therefore, the old method of swaging between die and counterdie is still generally followed, even though it is quite

[1] "American Textbook of Prosthetic Dentistry."

[2] *Ibid.*

[3] *Ibid.*

well recognized that *perfect adaptation* to the form of the arch is thereby never realized.

The cast aluminum plate, owing to the present method of casting, has recently received quite an emphatic endorsement, and if the future proves corroborative of the good results claimed for this method, it is likely to be much more generally adopted as a method of restoration than in the past.

The Use of Clasps.—It is often difficult to decide as to the advisability of utilizing clasps as a means of retention. While their use affords material aid in supporting a denture in position, and as this must be measured in importance proportionate to the difficulties of effecting satisfactory retention without their use, nevertheless, the adjustment of a clasp is not without serious disadvantages, tending toward the loss of the tooth through the additional strain imposed upon it, or the destruction of its substance owing to the lodgment of food débris and septic organisms between the clasp and tooth. In view of the earlier loss of the tooth because of the adjustment of the clasp, which, sooner or later, will make it necessary for the patient to retain the plate in position without the service rendered in this relation by the use of the clasp, therefore, this might have been done in the first place, and the natural tooth conserved for a greater period. It must not be overlooked, however, that the presence of a partial plate in the mouth is also a factor tending toward the loss of remaining teeth, and, if the use of a clasp will make it easier for the patient to establish a *tolerant state* more quickly, the adjustment of the clasp in the final analysis of all the related factors is justifiable, even though the loss of the natural tooth is thereby somewhat hastened.

The Use of Telescoping Crowns.—In place of the clasp, telescoping crowns may be utilized to retain the plate in position. These are constructed similar to the method adopted in removable bridgework (see chapter on Bridgework), and when the indications admit of their use, very satisfactory results may be attained in their utilization..

CHAPTER XXVI

IMPRESSIONS

When the conditions prevailing in the mouth are satisfactory, and when a base and the type of denture have been decided upon, as discussed in the preceding chapter, we may proceed with the taking of the impression.

This is generally regarded as a very important step in the procedure of plate construction, and, as much of the success of the final result is directly related to the accuracy of the impression, it is necessary that in all cases sufficient care must be exercised that a satisfactory impression may be obtained.

Impression Materials.—The materials usually employed for taking an impression are plaster of paris, modeling compound, bees' wax, and the preparations of wax and paraffin, and wax and gutta percha. Bees' wax and its compounds are now only used in conjunction with plaster of paris, or for the purpose of securing the "bite"; at no time is any one of these preparations utilized *per se* for securing the imprint of either jaw from which a plate is to be constructed. For this purpose, at the present time, wax is valueless. The force required to secure the imprint of the arch displaces the soft tissues; its tendency to distortion in the act of withdrawal, and the marked change of form which characterizes the mass upon cooling render it useless for taking an impression in comparison to the superior results obtainable in the use of plaster of paris or modeling

composition. It may be made, however, serviceable when used, as previously indicated, in conjunction with plaster of paris when compression of soft areas is indicated, or in partial cases, and, while modeling compound may be utilized for a similar purpose, the use of wax facilitates the subsequent removal of layers of the material to provide space for the addition of the plaster for the final imprint.

Plaster of Paris.—Chemically this is known as calcium sulphate with a formula of $CaSO_4$. Commercially it is prepared from *gypsum* by removing its water of crystallization and reducing it to a fine powder. When intended for use its water of crystallization, originally removed by heat, is added to the powder, which induces a return to its natural state; this is the so-called "setting" of the plaster. When the admixture of water and powder has been satisfactorily made, the mass is conveyed to the mouth upon an impression tray and allowed to harden. No compression of tissue occurs, unless used, as previously indicated, in conjunction with either wax or modeling composition as a base, and it perfectly adapts itself over the entire surface to which it is applied. If undercuts exist, the material fractures in the act of withdrawal, with sharp, well-defined edges which readily admit of accurate apposition; this, therefore, can not be urged as a serious objection to its use. Plaster undergoes a change of form in the setting process, expanding about 1/500 of its volume, but, as this may be almost entirely controlled by proper mixing, and by the addition of potassium sulphate to the water used in mixing, the very best results in prosthetic efforts are alone possible when plaster is used for taking the impression. It is generally admitted that, in proportion as the case presents difficulties, or that an ac-

curate reproduction of the form of the arch or any part of it is necessary, so is a plaster impression indicated. For an impression a very finely ground preparation is used, that its "setting" may not be too long delayed. The coarser the plaster the slower it "sets," and the harder it becomes. This is the variety usually employed in pouring the model, as it is desirable to have the model set harder than the impression.

The setting of the impression, which takes place in from three to five minutes, may be hastened by the use of *warm water* in mixing the plaster, or by adding *salt, potassium sulphate, alum,* etc., to the water used in making the mix. Five grains of sodium chlorid added to an average mix will reduce the time of setting to from two to three minutes. This may be further reduced by the addition of larger amounts of sodium chlorid until thirty-two grains are added, when the mass will set in about one minute. The addition of still larger amounts lengthens the setting period. These facts were first determined by the investigations conducted many years ago by Dr. J. W. White.

More recently it has been experimentally determined [1] that increase in the amount of stirring increases the expansion and reduces the setting time, in view of which it is best to subject the mass to the least amount of stirring conducive to a homogeneous mix. Dr. Prothero's investigations disclosed the following facts: The expansion of the mass occurs immediately upon mixing and continues for about four minutes, when its greatest index is reached. It is about completed in ten minutes. Sulphate of potassium is the best substance to admix with the water to prevent expansion, and the

[1] J. H. Prothero, *Dental Digest*, 1903; S. J. Spence, *Items of Interest*, Vol. XXIV.

best results are obtained when the admixture is made in definite proportions. He recommends the following: Water, 40 c. c.; plaster, 55 grms.; potassium sulphate, 0.33 grm. Furthermore, as previously stated, the temperature of the water is also a factor in the setting of the mass. Warm water reduces the time of setting, while cold water increases it. It will also be found that the exposure of the plaster to moisture will change its setting property. When ready for the mix, about two tablespoonsful of water are placed in the bowl, to which 5 grains of sodium chlorid are added, and the plaster slowly dropped from the end of the spatula until it reaches a level just below the water; the excess water is then poured off, and the spatula introduced with a cutting movement, the bowl at the same time being rotated, until each particle of plaster appears to be in contact with its quantity of water; the spatula may then be rotated several times through the mass and the mix is completed. The procedure should not take more than ten seconds, and is planned to admit of a chemical satisfaction between the water and plaster, to the exclusion of air, which should be given every opportunity to escape from the plaster, if the best results are to be obtained.

Modeling Composition.—This consists of gum dammar, stearin, French chalk, coloring and flavoring substances, etc., softens when placed in water near the boiling point, in which state it easily takes an impression, which is retained upon its surface during the cooling period, but is liable to slight distortion in the act of withdrawal. This makes it unsuitable in partial cases, also in full cases, where deep depressions exist in the region of the incisor and bicuspid teeth, owing to the canine eminence. Far more satisfactory results, how-

ever, may be obtained by its use than with bees' wax. It may also be utilized for securing an impression when a cast is desired for further study, before definitely concluding as to the nature of the restoration to be made, or in those cases, fortunately only occasionally presenting, where a peculiar antagonism is shown by the patient toward the introduction into the mouth of the plaster mix, which immediately upon contact with the mucous surface results in nausea and vomiting, which cannot be controlled by the usual therapeutic applications, therefore enforcing the hasty removal of the impression material. In softening the material, when intended for use, it should be thoroughly manipulated between the fingers and frequently immersed in the heated water, to reduce the mass to the best possible state for the impression. It should be allowed to cool slowly and thoroughly before removing it, under which treatment satisfactory results may be secured.

Impression Trays.—This is the vehicle whereby the impression material is carried into the mouth, and which it supports during the hardening process, also in the act of removal, that it may retain the imprint upon it as secured during the taking of the impression. The importance of a suitable tray in relation to the impression can scarcely be overestimated, and many careful prosthodontists swage a special tray for almost each case, in order that the very best results may be attained. This is an excellent plan and should be followed whenever it is found that no impression tray can be secured that will afford a favorable adaptation of the impression material. In a general manner the tray should conform to the shape of the arch, and when in position should be sufficiently large that just about enough impression material can be carried to place for all practical pur-

poses. Fig. 135 illustrates a tray for a full upper impression with the deep heel designed for securing an excellent adaptation of plaster to the posterior portion of the arch. Fig. 136 illustrates a tray for partial upper impressions, and Fig. 137 is also for partial upper impressions with adjustable sides. Several sizes of

FIG. 135.

each of these forms will be found to meet the usual requirements. For special cases a tray may be swaged as previously indicated.

Figs. 138 and 139 illustrate trays for full and partial lower impressions. In adjusting the tray to note its adaptation prior to taking the impression, it will usually be found that some bending and cutting are nec-

essary before the tray meets the requirements of the case. As a rule, it will be found that time consumed in this manner is not lost, and that ample compensation is secured in the superior results attainable through a satisfactory impression, which can readily be taken when

FIG. 136.

FIG. 137.

the impression tray meets the requirements of adaptation.

Full Upper Impressions.—When all the preliminary details have been carefully attended to, as previously discussed, the patient is next prepared for the taking of the impression. It is a good plan to assure the patient that what is about to take place will only slightly inconvenience him, and will be but of short duration. When this is done the patient is better prepared to meet the disagreeable effect of the plaster of paris when first

introduced into the mouth, and with the knowledge that but a few moments will elapse before the withdrawal of the material, he usually makes the effort to endure the discomfort, and thus aid the operator to secure the desired result. Having mixed the plaster, as previously discussed, a suitable amount is placed upon the tray,

FIG. 138.

FIG. 139.

and, having wiped the arch with a napkin, a small quantity of plaster is placed by means of the spatula against the roof of the mouth, and in the region of the tuberosities, and the tray with the plaster upon it quickly introduced and adjusted to the tissues. The preliminary introduction of a small quantity of plaster against the roof of the mouth, and the tuberosities, is favorable for a satisfactory result, as so many impressions will be found to be defective, especially in the region of the max-

illary tuberosities, when this recommendation is not followed.

In making the adjustment of the plaster to the oral tissues, the heel of the tray should first be adjusted to the posterior part of the arch. The patient's head is next brought forward, and by pressure the tray is gradually forced into position, care being taken that all the retained air between the roof of the mouth and the impression material is expelled, and that the lips and cheeks are pulled out and pressed downward, that the frena may be correctly marked upon the impression. All possibility of displacement of the tray is guarded against by firmly supporting it in its position until the impression is withdrawn from the mouth.

The impression is not to be withdrawn until the plaster has sufficiently "set" to prevent distortion in the act of removal. A reliable test is to break a projecting piece of plaster, and if it fractures with sharp, well-defined edges, it has become sufficiently hard for removal. Its removal may be facilitated by drawing the lip and cheeks away from the impression, to admit air to this portion of the impression, and by forcing the handle of the tray first upward and then downward, and, repeating these movements, the impression is loosened and may be withdrawn from the mouth. In many instances it will be found upon removal of the impression that the force necessary to dislodge it has resulted in fracture. This usually occurs in the region of the deep depressions overlying the incisor and bicuspid teeth, also at the tuberosities. The fractured parts should be secured, carefully washed free of saliva, and returned to their correct positions upon the tray.

Full Lower Impressions.—Many operators find it more difficult to secure an accurate lower impression

than one of the upper arch. The difficulty, in most in- stances, is associated with the selection of an ill-fitting impression tray. When a poorly adapted lower tray is selected and carried to place for the impression, it invariably presses too hard upon the tissues in the posterior part of the ridge, resulting in pain and a restlessness upon the part of the patient which interferes with the steady contact of the plaster against the tissues, and leads to a faulty impression. The selection of a properly formed lower tray for the case is, therefore, a very important preliminary requirement for the securement of a good impression. Having selected the tray, the plaster is mixed somewhat thicker than for upper cases, and the material introduced into the mouth. The lip and cheeks are next drawn out, and the patient directed to extend the tongue outwardly. This forces the plaster well against the inner anterior portion of the ridge, and is an important act tending toward a satisfactory impression. It will be found that lower impressions must be retained in position for a longer period than upper impressions, as the presence of saliva retards the setting of the plaster.

Partial Plaster Impressions.—Several methods have been recommended for taking impressions when two or more natural teeth remain in the arch. In one the tray is removed from the plaster, having been previously oiled to facilitate its removal, and the impression taken out in sections. To accomplish this the plaster must be cut down almost to the natural teeth, and by inserting the blade of a knife into the cuts, the several sections are removed from their position, and later assembled upon the plate, being guided into correct position by the lines of fracture. This method is open to the objection of consuming considerable time, which is lost if

e impression is not satisfactory. The determination the lines of fracture by a division of the impression y has been suggested by Valderrama.[1] "An impres- n tray suited to the particular case is divided into r pieces, as shown in Figs. 140 and 141; the front

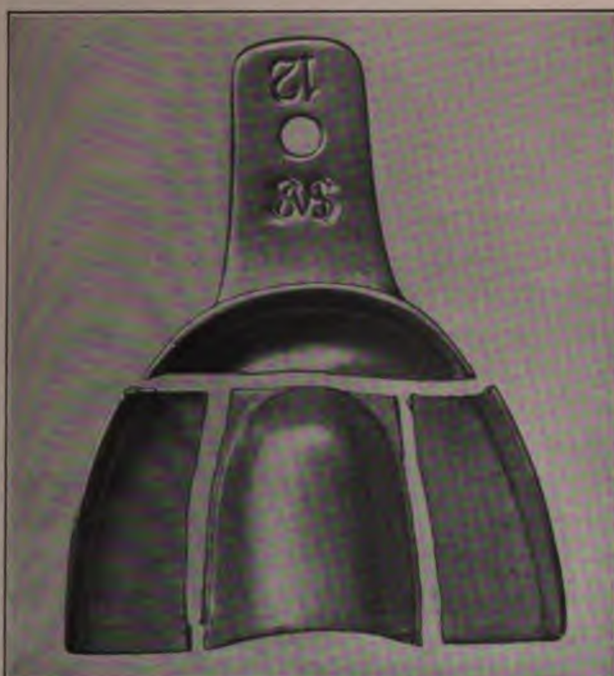

Fig. 140.

ece embraces the incisors and possibly the canines, e two lateral pieces the teeth beyond the canines, d the fourth piece the root of the mouth. The four eces are then waxed together with hard wax, and the pression is taken in the usual way." The blade of knife inserted between the sections of the tray, after

[1] *Dental Cosmos*, 1902.

the plaster has set, will cause it to separate into four pieces.

Another method commonly practiced is to utilize wax in combination with plaster to take the impression. In this method the wax may be adjusted to the tray to cor-

FIG. 141.

respond to the position of the natural teeth, and an impression taken. Plaster is then applied to the tray in the usual manner, and reintroduced into the mouth, being careful that the teeth occupy the impression in wax previously made. But little difficulty will be encountered in removing the impression when the plaster has set.

The results obtained by this method are usually satisfactory.

Another method of utilizing wax in combination with plaster, which by many is preferred to the procedure previously discussed, and which is utilized not only for partial but for full impressions as well, is first to secure an impression in wax; when this has been satisfactorily accomplished, a section of the palatal portion of the wax is removed to accommodate a mix of plaster of paris; this is then added, and the wax impression with the added plaster is again adjusted to the arch and an impression taken. When this is removed it will somewhat resemble a plaster impression. An objection urged against this method of obtaining an impression is that, if the plaster is fractured in the act of withdrawal, the pieces are too thin and small to allow of accurate réadjustment. While this may be so in a small number of cases, it is not so in a very large number, in which the method may be successfully employed for obtaining excellent impressions.

Cases occasionally present where an accurate adaptation of the plate has been obtained, and where the teeth are in proper occlusion, but the patient finds that the denture will not remain in position when force is directed against it. This is usually due to soft areas overlying the ridge, hence, when force is directed against the plate, as in mastication, it yields where the soft areas are to be found, and, being more or less, unyielding over the remaining portion of the mouth, it cannot be retained in position. It is quite evident that the indicated procedure here is to construct the plate so that when in position compression of the soft areas is realized, the unyielding bed of the plate then being able to resist stress. The compression of the soft tissue may be obtained by

observing the location of the soft areas in the mouth and scraping the plaster cast in parts indicating the location of the soft areas. No matter how carefully this attempt at scraping the cast may be performed, it is inaccurate. A better plan is to effect the compression of the soft areas, in the act of taking the impression, by means of the impression material. This may be accomplished by the use of either modeling composition or bees' wax, and has been previously alluded to. But as neither of these materials, as noted, affords a satisfactory impression in other respects, their utilization is impracticable, no matter how desirable they may be, because the case at hand may demand compression of soft areas. The plan usually adopted in these cases is to take the impression first in wax, remove several layers of the palatal portion of the wax impression to provide space for a mix of plaster, which is placed upon the wax and the tray reinserted in the mouth. By this means we secure the advantages of a plaster impression, also whatever advantage may accrue from the use of a minimum amount of plaster, as contended by some, also the compression of the soft areas as is attested by the satisfactory result obtained when the denture is constructed from such an impression.

In those cases where one or more teeth of unusual length remain in the arch, considerable difficulty may arise in securing a satisfactory impression, unless some means is adopted of eliminating the remaining natural teeth as the factor of interference. This may readily be accomplished by cutting openings into the tray through which the crowns of the natural teeth may extend when the tray is adjusted for the impression. To facilitate removal of the impression when the form of the natural teeth, or the mass of impression material

about them, would make removal very difficult, it is recommended [1] to adjust cylinders of tin or wax about the openings at least twice as wide as the natural crowns. These are secured to the tray by means of melted wax. When the plaster impression has hardened, the cylinders are removed from the tray, and by means of a knife a groove is cut into the plaster projection until the blade of the knife is in contact with the natural tooth within the plaster. By introducing the blade into the groove the plaster cylinder may be split into two parts. The impression is now withdrawn and the plaster cylinders readily adjusted to it.

In some cases it may be desirable to accurately reproduce in plaster the form of teeth with an occlusal dimension wider than a cervical. To accomplish this a section of rubber tubing is slipped over the tooth, the opening being just enough to provide for a satisfactory adjustment of the tubing at the cervical portion of the tooth. The tubing should extend from the gum margin to the widest portion of the tooth. The natural tooth and the rubber ring in position are now well lubricated, and an impression in plaster taken. When the plaster model is prepared the thickness of the tubing is clearly represented in plaster, and may easily be cut down, leaving the form of the plaster tooth as a very accurate reproduction of the natural crown.

The accurate reproduction of bell-shaped teeth, or of a wedge-shaped space, may also be accomplished by taking the impression in two halves. The impression material is introduced from the lingual aspect and extended buccally to cover somewhat more than one-half the tooth or space. When the impression has hardened it is removed by forcing it out lingually; it is next

[1] "American Textbook of Prosthetic Dentistry."

trimmed down to just cover one-half the form to be reproduced, and varnished. It is now adjusted to position, and new impression material applied to cover the buccal half, and perfectly adapted against the lingual half of the impression previously adjusted to place. When the material has hardened, it is removed in two sections, by inserting the blade of a knife where the two halves meet; these are waxed in position and the model poured.

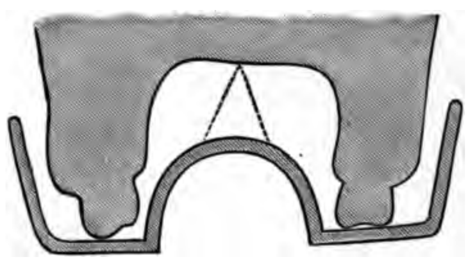

FIG. 142.—SECTION THROUGH UPPER JAW WITH ALVEOLAR UNDERCUT SHOWING TRAY IN POSITION, AND MANNER OF MAKING WAX ADDITION. ("American Textbook of Prosthetic Dentistry.")

The sectional removal of the impression is also indicated where natural teeth remaining in the arch converge, which, together with the presence of a deep vault, would make it almost impossible to remove the impression in one piece. Fig. 142 illustrates a case of this type. The procedure here is to adjust a wedge-shaped piece of wax or modeling composition as indicated by the dotted lines in the illustration. This is secured to the tray by heat and oil applied to it and to the interior of the tray. The plaster mix is now added to the tray and the impression taken. When the material has set the tray is removed, the wedge of wax or compound usually coming away with it. The outer portion of the impression is next detached, and if the compound is still in position in the mouth it may easily be detached and adjusted to the plate; the remaining portions of the impressions are now readily removed, and all the parts carefully assembled upon the plate, and the model prepared.

When an impression is taken into which molten metal other than the fusible alloys is to be poured for a metallic cast, the impression should be taken in a combination of plaster and marble dust. Pumice or whiting may be used in place of the marble dust, but in any instance much more time must be allowed for the setting of the impression than when plaster alone is used. When the impression is removed it should be thoroughly dried before pouring the metallic cast.

CHAPTER XXVII

CASTS: THEIR FORMATION AND PREPARATION—THE PRINCIPLES OF PLATE RETENTION

The formation of a satisfactory plaster cast is as necessary for the success of the prosthetic effort as the securement of a satisfactory impression. While the cast is the plaster counterpart of the impression, and as such reproduces any defect to be found upon the impression, its relation to a successful denture is not only dependent upon the impression, but also upon the manner in which the requirements of a satisfactory cast are realized. These requirements embrace *the proper treatment of the impression, the use of the proper kind of plaster for forming the cast,* and *its application to the surface of the impression, after the mix with water is made, to insure that a perfect surface may be formed for the cast.*

Treatment of the Impression.—Having obtained the impression after one of the methods discussed in the preceding chapter, it is set aside to harden for about a half hour, when a thin coating of shellac varnish is applied over its entire surface by means of a camel's hair brush. The plaster readily absorbs the varnish and is thereby colored a light brown. When the shellac varnish has thoroughly dried, a coating of thin sandarac varnish is applied, which, owing to the non-absorbent surface of the plaster, made so by the previous application of the shellac varnish, produces a glaze upon the surface of the impression without destroying the fine

linear markings upon it. Both the shellac and sandarac varnish should be rather too thin than thick, as the latter, if used, will obliterate the fine lines of the impression and lead to the formation of an imperfect cast. The use of an additional coat of oil, following the varnish, recommended in some quarters, is not only unnecessary, but may injure the cast by making its surface soft if more than just the thinnest coating of oil is applied.

The use of a solution of castile soap in water, in place of the varnish, has also been suggested, and may be successfully employed. Varnishes, one coat of which both stain to some depth and glaze the surface of the impression, have also been advised, but the results obtained by the use of shellac and sandarac varnish, as previously indicated, are generally preferred.

If the impression is that of a partial case, it is prudent to insert an ordinary pin with its head nipped off, and oiled, into the impression of each tooth. This prevents fracture of the plaster tooth in the act of separating the impression from the cast, and allows of the removal of the pin from the plaster tooth, if this should be desirable in the subsequent steps of the procedure.

Lower impressions are to have a piece of sheet wax adapted to their inferior border, that a smooth, flat surface may be reproduced upon the cast.

When the impression has been taken in modeling composition, no treatment beyond placing the impression beneath running water is indicated. The surplus water is forced out, as it is but desired to have a moist surface for the free flow of the plaster in forming the cast.

Wax impressions should be coated with a layer of sandarac varnish preparatory to pouring the plaster. The wax may then be separated from the cast, if not

heated excessively, without adhering to the surface of the plaster.

The Variety of Plaster.—In the preceding chapter, in discussing the use of plaster of paris for taking impressions, reference is made to the fact that the variety employed in forming the cast differs from that utilized in taking impressions. In the latter instance a fine powder is utilized which sets more promptly than the coarser powder, and does not attain its hardness. But as the hardness of the coarser plaster would only increase the difficulty of its removal, especially in partial cases, and as its delayed setting is anything but agreeable to the patient, this variety is never employed for taking impressions. But the increased hardness is desirable in the cast, and, as the delayed setting is not disadvantageous, the coarse variety is utilized in forming the cast.

In the chapter referred to above reference is also made to the experiments of Dr. J. H. Prothero [1] concerning the expansion of plaster during its setting, and the method by which this may be almost entirely controlled. The addition of potassium sulphate, and the manner of making the mix being, as previously discussed, the factors through which this is attained. These experiments have been confirmed by others.[2]

In the *Cosmos*, 1905, Dr. George H. Wilson reports experiments with plaster which appear to throw additional light upon the attributes of a plaster mix. He emphasizes the importance of a correct method of mixing the plaster and water, also of maintaining a definite ratio between the powder and water. A faulty mix or an unsuitable plaster may account for changes that will result in an ill-fitting denture, but when these fac-

Dental Digest, 1903.
"American Textbook of Prosthetic Dentistry."

tors are eliminated, and a suitable plaster utilized and properly mixed, the slight expansion which may take place cannot be considered to be the factor which explains the faulty adaptation of the plate.

In the experiments conducted by Dr. Wilson previously alluded to, the *compressibility of plaster* is regarded as the factor of importance in relation to failures in prosthetic efforts. Dr. Wilson writes as follows: "The writer believes that this property of plaster accounts for more failures in prosthesis than all other causes, barring a lack of knowledge and manipulation.

"The testing of this property of plaster has been done with a lever upon a freely sliding plunger one-half inch in diameter. The plaster was placed in the lower half of a vulcanite flask, as the unconfined plaster would crush and give no satisfactory test of compression. The first series of tests was with French's regular dental plaster, to determine the time at which it reached its greatest degree of hardness. The conclusions were that, with two measures of plaster to one of water, and with minimum stirring, the greatest resistance to pressure was reached between twenty and twenty-five minutes. The tests were carried through a period of twenty-two hours. Other brands of plaster varied very materially, some requiring between one and two hours. The next series of tests was to determine the length of time during which compression took place. As near as the eye could determine the compression was complete in about five or ten seconds; fifteen minutes' application of a given pressure made no perceptible increase."

Concerning the *Spence plaster compound,* Dr. Wilson writes as follows: "It requires a small quantity of water and much kneading. A suitable mix can be made

with three to three and one-fourth measures of plaster to one of water, which will not break the glass beaker; but upon working in more compound some expansion will be developed. In thirty minutes the material will resist a greater force than French's regular dental plaster, but its maximum strength is not developed for about two hours, when one thousand pounds pressure will not make the impression that two hundred and fifty pounds will upon ordinary plaster. The material is hard to mix and is very coarse grained. I use it for making casts by lining the impression with a thin layer of regular dental plaster, and the Spence compound is packed into the soft plaster lining. By this means I obtain a cast that is smooth and dense upon its surface and has great strength."

Forming the Cast.—When the impression has been prepared, as previously indicated, a quantity of water is placed in the rubber bowl, and plaster slowly added until it reaches just below the level of the water line. The slight excess water should be poured off and the mix made according to the method outlined in the preceding chapter. The setting of the plaster should not be hastened by the addition of any of the substances recommended for this purpose, as the utmost hardness is desirable in the cast, and this cannot be obtained if any one of these substances is used. The mix having been made and the surface of the impression wetted, a quantity of the plaster mix is placed upon the highest part of the impression, and by gently tapping the tray upon the table the plaster seeks a perfectly even distribution over the surface of the impression. In partial impressions care should be taken that the impressions of the teeth are not filled with water, and that the plaster very gradually flows into these impressions for the perfect

reproduction of the teeth upon the cast. More plaster is added until the entire surface of the impression is covered, and further additions made with the spatula until a satisfactory depth may be obtained for the cast. The tray is then inverted, and placed preferably upon a glass slab, that the base of the cast may have a perfectly smooth surface. The sides are next smoothed by means of the spatula, and the case set aside for at least thirty minutes before any attempt is made to separate the cast.

Separation of Cast.—When wax, or modeling composition, has been utilized as the impression material, the softening of either material by means of heat will readily effect its separation from the plaster cast. The method of placing the cast and impression in heated water, which slowly softens the impression material, but which allows of the impregnation of the cast with water, rendering it quite unfit for use until the moisture has been removed, is strongly condemned by many prosthodontists. Preference is given to the method of placing the cast and impression upon a heated plate of metal, the heat of which may be slowly raised, gradually and thoroughly softening the compound, or wax, admitting of its easy removal from the plaster cast. In removing the impression material from the cast, in partial cases, care must be exercised not to fracture the plaster teeth in those cases where they have not been supported by the adjustment of the pins to the impression.

When the impression has been taken in plaster it is more difficult to separate the cast, although with care it may easily be effected without in any way marring the surface of the cast. The method is first to remove the excess plaster upon the sides of the cast and upon

the impression tray, exposing the edges of the tray, which may then by tapping be readily removed from its position. If tapping fails to dislodge the tray, it should be placed upon a warm plate and slightly heated, after which it may easily be dislodged. The plaster cast and impression are now trimmed down until the line of varnish separating them appears. Grooves are next cut into the impression in such locations as will allow the removal of sections of plaster of the impression without in any way endangering the integrity of the cast. The temptation to remove large sections of the impression at one time is likely to end in injury to the cast, therefore should be avoided. Simple as the procedure of forming the cast appears to be, it is only after considerable experience subjoined to a desire to master the apparently simple technique that satisfactory results in forming the cast are attained, and in most instances the expert worker is recognized in the lines of the formed cast.

The Use of Spence's Plaster for Casts.—As previously stated, in referring to the experiments of Dr. George H. Wilson, the use of Spence's plaster results in the formation of a cast possessing great strength, much greater than that formed of the ordinary plaster; and as this is an advantageous factor in the construction of vulcanite dentures, its use in this relation is strongly advised. The procedure is to use a thin layer of regular dental plaster over the surface of the impression. When this has been done the Spence's plaster, which should be carefully mixed, is thoroughly packed into the soft plaster lining by means of the spatula until the desired depth of the forming cast has been reached. According to Dr. Wilson, the maximum strength is not developed for about two hours, when one thousand pounds pres-

sure will not make the impression that two hundred and fifty pounds will upon ordinary plaster.

When the cast has been formed it should now be carefully studied in order that definite conclusions may be reached as to the general plan of the plate to be constructed. This is especially demanded in partial cases, where clasps are to be utilized for the retention of the plate. While in some particulars definite conclusions must be reached as to the type of denture prior to the formation of the cast, as, for example, whether a vulcanite or metal base is to be constructed. If the former, the form given the cast is different from that given the cast when a metal base is to be utilized; here the cast has sloping sides converging from the base to the face of the cast, which form is necessary for the production of the mold; while if vulcanite is to be utilized, the base of the cast is trimmed down, that it may be set in the flask. But in regard to the outlines of the plate, the method of securing retention, and any other detail which may promote the retentive features of the plate, or which may be deemed vital in any other relation, should now be given careful consideration, that the very best plan of construction may be adopted, and when the definite conclusions in this regard have been formed, the general technique of construction may be proceeded with without hesitation.

Outlines of the Plate.—In all cases of plate construction its outlines have an important bearing upon the success of the denture. In full cases, extending the plate too far backward, or allowing the plate to come in contact with the buccinator muscle in the region of the bicuspid teeth, will seriously interfere with its retentive feature, no matter how perfectly the plate may have been constructed in every other respect. It is well, then,

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to carefully observe the anterior line of movement of the soft palate. As the location of this line varies in different individuals, from the end of the hard palate to a line considerably in advance of this, Dr. Burchard advises that the patient be made to pronounce the syllable "*Ah*" with the mouth wide open, that the line at which the muscular movements cease may be noted. The difficulty that may arise in concluding just where to mark the posterior outline of the plate is due to the fact that at this line it is most difficult to exclude the air; therefore, it is desirable to place the posterior margin of the plate upon soft tissue, and by scraping a line upon the cast, a contact will usually be obtained advantageous for the exclusion of air. This may also be the indicated procedure where the softness of the tissue overlying the alveolar ridge, in the anterior part, permits more or less movement in this region under stress, and, if the posterior border of the plate is not extended backward, as indicated, to avoid contact with the posterior end of the hard central ridge, the plate cannot be successfully retained under stress. But the encroachment of the plate upon the soft area must be very slight, otherwise the advantage gained, as noted, will be lost in the displacement effected by the movements of the muscles of the soft palate.

In the anterior region the outline of the plate must be carried low enough to avoid the frænum of the lip. In the region of the bicuspids, as indicated, the outline should be placed low enough to escape the buccinator muscle. These are the low lines of the plate upon its labial and buccal aspects. Its high lines are represented by the canine eminence and the tuberosity, from which latter position it is rounded into the line marking its posterior border. Not only must this outline be fol-

lowed, as here indicated, in order to meet the anatomical relations of the plate, but in so doing we obtain an adaptation which will serve best for the exclusion of air, which also is essential for the successful retention of the plate. While it is desirable to secure satisfactory results in all cases of plate construction, the necessity for carefully observing all the details involved increases as the form of the arch and the excessive resorption of the alveolar ridge are unfavorable for plate retention. A mouth with a deep-pointed vault, or the flat mouth with little evidence of an alveolar ridge, are instances of unfavorable conditions for plate retention, and the resourcefulness of the most skilled at times is alone adequate even for moderate success. While in all instances, as previously stated, careful attention should be given to all details related to the constructive effort, beginning with the conditions of the mouth preliminary to taking the impression, and terminating with the final polishing of the finished piece, as indicated, this finds most forceful application in those cases generally regarded as most unfavorable for plate retention. Among the details of the procedure, obtaining the correct outline of the plate occupies a prominent part in the success of the denture.

When the correct outline of the plate has been obtained, it is customary to scrape the cast across the labial and buccal outline that a closer adaptation of the plate may be secured in this region. This may also be done at the posterior outline across the vault, when the plate is constructed not to rest upon the hard median ridge. This procedure is contraindicated when the posterior outline cannot be carried beyond the distal end of the ridge, owing to the muscular activity of the soft palate. To do so in these cases would result in the plate press-

ing too hard upon the end of the hard central ridge, and lead to its displacement under stress of mastication. Prior to scraping the cast, as indicated, it is best to examine the tissue to be affected that an abnormal degree of compression may be avoided. In some cases the tissue overlying the bone is soft, admitting of a greater degree of compression than when it is found to be dense and unyielding. In no instance should more than 1/50 of an inch in thickness be scraped from the cast.[1] Many prosthodontists follow the method of Dr. W. Storer How, of forming a groove in the cast with a spoon-shaped excavator following the outline of the plate. This is reproduced in the vulcanite plate as a well-defined line. In the swaged plate a half-round gold wire about 18 gauge may be soldered to the end of its inner surface. When the air has been exhausted and the plate drawn to place, the tissue in contact with the bead upon the inner surface of the vulcanite plate, or the wire upon the gold plate, is compressed. If from the constant pressure upon the tissues in the marginal regions resorption occurs, the margins of the plate are still slightly imbedded in the tissues and tend to prevent the ingress of air. If the contact of the elevation upon the inner surface of the plate with the mucous membrane is too severe, it may be trimmed down and the pressure relieved.

Reference has been made in the preceding chapter, in discussing Impressions, to the existence of soft areas in the mouth, especially along the alveolar ridge, and to the necessity of effecting compression of the soft parts, to avoid displacement of the plate under stress of mastication. The plan, followed by some, of locating the soft areas upon the cast and then scraping the cast

[1] "American Textbook of Prosthetic Dentistry."

that the desired compression of the soft areas may be obtained, at best is an inaccurate procedure. If it is doubted that an adequate compression has been secured by taking the impression in a combination of plaster and wax, the following plan will be found to yield very satisfactory results: The *hard area* (usually the central ridge) is marked upon the cast, and additions made upon the cast in the marked area, that the finished piece may be relieved in this region. For a vulcanite plate the additions to the cast may be made of three layers of No. 60 tin foil secured in position with liquid silex (Fig. 143). When the cast is intended for a swaged plate the addition may be made with wax. This method of relieving the plate in the region of the hard areas is to be preferred to that of scraping the impression in these areas. By the former method the degree of relief is clearly indicated; by the latter it can only be surmised.

FIG. 143.—THE VACUUM FORM. ("American Textbook of Prosthetic Dentistry.")

The imperfect reproduction of the *rugæ,* especially in swaged plates, at times may have an important bearing in effecting displacement of the plate. It is generally an indicated procedure to exaggerate the rugæ by additions of wax upon the cast, when this is utilized as a model for the die, in order that they may be adequately reproduced upon the plate, and avoid the undue compression of these folds of membrane. When this course is not adopted, the rugæ are imperfectly reproduced in

the swaged plate; hence, when the plate is placed
the mouth, and the air exhausted by the action of the tongue and muscles of the throat, the rugæ are compressed and the plate appears to be perfectly adapted; but, with the return of the blood, momentarily forced out by the compression of the plate, the perfect adhesion of the plate is destroyed and displacement takes place, which cannot occur if the rugæ are enlarged upon the cast.

The Vacuum Chamber.—This is a space created in the palatal portion of the plate for the exhaustion of air, by which means atmospheric pressure is utilized as an aid in the retention of plates for the upper arch. The first use of the vacuum form in artificial plate work is credited to W. H. Gilbert of Hartford, Conn., in 1840.[1] In 1850 Dr. John A. Cleveland[2] of Charleston, S. C., introduced what is known as the Cleveland vacuum chamber. This form of vacuum chamber, which will be described later, never enjoyed extended usage, owing to the marked irritation of the tissues which followed its utilization.

While the adoption of the vacuum chamber in the construction of plates for the superior arch is the rule of practice, it is not without opposition in some quarters. The opponents of the method contend that, as the tissues in a short time are drawn into the vacuum chamber, the exhaustion of the air from between the plate and the mucous membrane is completely, or nearly so, interfered with; hence, reducing to a negative degree the value of principle upon which the vacuum chamber is supposed to aid in plate retention. Furthermore, as its presence in nearly all cases is followed by consid-

[1] "American Textbook of Prosthetic Dentistry."
[2] *Ibid.*

erable irritation of the soft tissues, the disadvantages arising from this more than balance the supposed advantages. On the other hand, those favoring the adoption of the method contend that, even though the principle of atmospheric pressure may be active but for a short period, viz., until the tissues are drawn into the vacuum chamber, this is of material advantage in tiding the patient over what has been previously designated as the tolerant stage, i. e., until tolerance for the denture has been established. The claim is also made by those favoring the utilization of the vacuum chamber that, although the tissues are drawn into the form, they never completely fill the space; hence, a degree of air exhaustion and consequent pressure is always possible. Furthermore, as the site of the vacuum chamber in part covers the location of the hard central ridge, the relief obtained for the plate in this region is of decided advantage.

It may safely be stated that the general tendency is in favor of the utilization of the vacuum chamber, its advantages, when carefully planned, far outweighing its disadvantages; and while satisfactory results in plate retention may be obtained without its use, better results are likely to follow when, as previously stated, its construction is carefully planned in regard to its form and location, and the elimination of all that which tends to develop its disadvantages.

Dr. H. H. Burchard[1] offers the following plan for determining the location of the vacuum chamber:

"The slight movement usual with a plate during mastication tends to separate it from the mucous membrane and permit the access of air to its under surface.

"The line of least movement, as the movement is

[1] "The American Textbook of Prosthetic Dentistry" (second edition).

lateral, a rocking from side to side, is along the median line of the vault; and, as the concavity of the hard palate is usually of an irregular vault form, the point of least movement is near its apex. If the movement does not extend to an edge of the chamber, the stability of the plate is not materially affected, but when one of these edges loses its contact, air enters the chamber and adhesion is destroyed.

"The more closely the edges of the chamber approximate this line, the less tendency to disturbance there

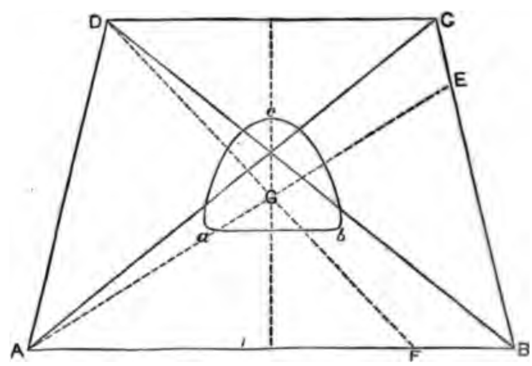


Fig. 144.—*A, B, C, D,* Trapezoid of the Superior Dental Arch; *G,* Center of Gravity of Figure; *A, G, E; D, G, F,* Gravity Lines, Their Intersections Marking *G.* (Burchard.)

is, so that comparatively narrow chambers are to be preferred; but the depression should be of sufficient size to not materially lessen the effects of a partial vacuum. Naturally the chamber should be in the area of greatest stability, that of least movement. This area will be found around and about the center of gravity, and in shape resembling the outlines of the dental arch.

"The dental arch represents approximately a parabola in outline. This encloses a trapezoid, the centers of the canines marking the extremities of the short, the centers of the third molars those of the long, parallel sides. Straight lines, joining these points, complete the

figure. The center of gravity of a trapezoid is found by suspending it first by an obtuse angle, and next by one of the acute angles; vertical lines dropped from the points of suspension will, in intersecting, mark the center of gravity. Thus, on the diagram (Fig. 144, A, B, C, D), suspend it first from the angle A, D, C, and drop a vertical D, F. Suspend from the angle B, A, D, and drop a vertical A, E. Their intersection at the point G is the center of gravity, which is posterior to the intersection of the diagonals. About the center of gravity the vacuum chamber should be placed, its outline following that of the arch, on a smaller scale. In the vast majority of cases the center of gravity thus determined will be found at about the height of the vault.

"The ends or apex and angles of the chamber should be about equi-distant from the center of gravity. As a rule, the apex of the chamber as far in front of the intersection of the diagonals as the center of gravity is behind that point. To apply these facts practically as a guide to finding the correct position of a chamber, draw first on the plaster cast the median line of the vault. From the centers of the canines to the centers of the third molars draw diagonal lines, the diagonals of the trapezoid. When all the teeth are absent, draw the two diagonals from the positions formerly occupied by the canines to the centers of the tuberosities (Fig. 145). To find the center of gravity, draw from the

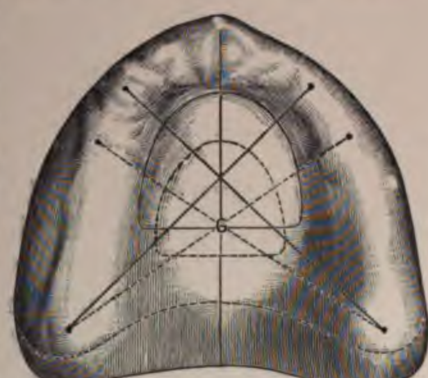


FIG. 145. (After Burchard.)

centers of both tuberosities lines to the junction of the first and second bicuspids of the opposite other lines, which intersect at a point of the median line G; this point will be the center of gravity of the trapezoid and of the palatal vault. The intersection of the diagonals will mark the focus of the small parabolic area to be covered by the chamber piece. Draw the parabola, its apex, about as far in front of the point of intersection of the diagonals as the center of gravity is behind the latter point, the angle of the parabola the same distance from the center of gravity as the apex. Should there

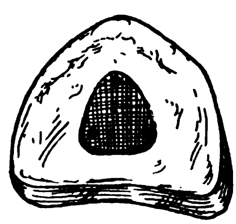


FIG. 146.

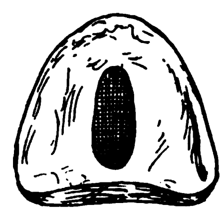


FIG. 147.

be a lack of harmony, of bilateral symmetry of the right or left side of the arch outlines, make the outlines of the chamber in correspondence."

Fig. 146 illustrates the general conformation of the vacuum chamber to the vault and alveolar ridge. It should be noted that the anterior border of the chamber should escape all, if possible, of the rugæ, and that in the desire to include within its location any bony elevation that may be found in the center of the vault, the posterior edge of the chamber is not placed too close to the posterior border of the plate.

Fig. 147 illustrates the form of chamber recommended by many when a hard median ridge is found in the upper arch.

When the tissue of the arch is soft the chamber may

be formed slightly deeper than when the tissue is more resistant. For the former its depth may approximate No. 14 (B. and S. gauge), and for the latter it may be reduced to correspond to No. 20 gauge.[1]

In vulcanite plates the vacuum chamber is formed by adjusting a form prepared from chamber-metal upon the cast, which is secured in position by pins, as indicated in Fig. 146. For the swaged plate a wax chamber form is suitably built upon the cast; this appears upon the die, and is reproduced in the swaged plate. Instead of preparing the wax model of the chamber upon the plaster cast, Dr. Wm. H. Trueman[2] recommends that the model of the chamber should be prepared from copper or brass, adapted to the die so as to be in its proper position, swaged between the die and counterdie, and prepared to the desired form (see Swaged Metallic Plates). In all instances every precaution should be taken to avoid the formation of a chamber that will unnecessarily irritate the tissues. Knife-like edges should be trimmed down, and all rough areas should be suitably polished. The location and form of the chamber should be correctly determined.

The Retention of Partial Upper Plates.—It is obvious that the easy accessibility of air to the palatal portion of partial upper plates diminishes their retentive feature, when this is sought through adhesion independent of any other force. Obviously, then, the sustaining effect of atmospheric pressure by means of the vacuum cavity is utilized in most cases, or the aid of tenso-friction, by means of the clasp, is depended upon. But in either case adhesion by contact is a contributory retentive means, and any treatment of the cast promoting

[1] "American Textbook of Prosthetic Dentistry."
[2] *Ibid.*

this, as considered in discussing the retention of full upper dentures, may be performed. If the posterior margin of the plate is placed upon soft tissue, the cast should be scraped in this region; or, if the denture is in contact with soft tissue in the labial or buccal alveolar region, this likewise is to be scraped.

Outline for Partial Upper Plates.—The plate should be placed in contact with remaining natural teeth at the cervical margin, if the aid which this contact affords in the retention of the denture is desired. But the destructive effect upon the teeth, owing to lactic acid fermentation, is usually more noticeable when the plate is placed in actual contact with the teeth, most likely due to the shelter thus afforded to microörganisms. The form and inclination of the natural teeth will usually determine if actual contact can be secured, or if the outline must be placed at a distance that the plate may be readily adjusted to position. When the artificial tooth is set upon the gum tissue in vulcanite work, the plate extends up to the tooth and not beneath it, as it does in a metal plate where the support of the plate for at least one-half of the cervical portion of the tooth is necessary. For esthetic reasons the unsightliness of vulcanite is best kept from view, so that the anterior teeth, including the first bicuspid of the upper arch, are set directly against the gum tissue, excepting in those cases where excessive resorption of the process demands substitution, when the plate outline is to be indicated, and the cast treated, as discussed for full dentures. When clasps are utilized the general method of construction is to considerably diminish the size of the denture by giving it a horseshoe form. This will be further discussed in treating of swaged metallic plates.

Retention of Full Lower Plates.—The difficulty of

satisfactorily retaining full lower dentures is so generally recognized that, only when the indications appear most favorable, as occasionally presents in a deep ridge showing little resorption, with firm tissue upon it, is the hope of even a moderate degree of success entertained. In these instances sufficient adhesion is secured to retain the denture in position, although the *weight* of the denture is an important factor in this relation. Some writers[1] regard the weight of the denture as the most important of the active forces of retention, although in some cases the posterior extension of the plate, so that it rests well upon the rami, or forming the denture with the deep lingual flange, or with the extension for the floor of the mouth, may aid in its retention by increasing the surface contact, hence the adhesion. Record[2] is made of a case where the extreme weight of the denture resulted in excessive resorption of the bone, which thereby became dangerously liable to fracture. The use of "weighed rubber," cast metal dentures, or any other method of construction designed to meet the indication of weight, should not be carried to an excessive degree. It has also been recommended[3] to construct the plate with a rim to be grasped by the muscles of the cheek and the lip, thus promoting its retention.

Outline for Full Lower Plates.—The necessity for avoiding muscular tissue must be as carefully observed in forming the outline for full lower dentures as was indicated when discussing the outline for full upper plates. Exceptions to this general procedure may arise when an extension for the floor of the mouth, or when

[1] "American Textbook of Prosthetic Dentistry."
[2] *Ibid.*
[3] *Ibid.*

the deep lingual flange is deemed advisable, as previously noted.

The muscular attachments to the labial and buccal surfaces of the mandible are at a higher level than those attached to the lingual surface; therefore, the outline when properly formed invariably gives the plate a greater depth in its lingual aspect than in its labial and buccal aspects. The precaution of avoiding the frænum of the tongue should be carefully observed. Some prosthetists favor a decided shortening of the plate in this region, also giving a decided concave form to the plate that the tongue may more readily rest against it and assist in its retention.

Outline for Partial Lower Plates.—The avoidance of tissue tending to displace the denture must be as carefully avoided here as in full dentures. The outline upon the remaining natural teeth is marked so that the finished piece rests upon one-half of their lingual surfaces. When an isolated tooth remains in normal relation to the ridge, the buccal line of the plate is made continuous and an opening formed, through which the tooth passes when the plate is adjusted to position. The tendency of the buccal edge of the plate to irritate the tissues of the cheek and lip makes it necessary to construct the plate that this should be avoided. A layer of wax is placed upon the cast where the edge of the plate would ordinarily meet the soft tissue, and shaded off to a thin edge upon the alveolar wall.

The addition of a thin layer of wax should also b made upon the ridge in those cases where it is fou to terminate in a sharp edge. This relieves the pr sure at this part, and prevents the irritation of the sue and considerable consequent annoyance to the tient. A plate so arranged exerts greatest pressu

upon the sides. When the lower anterior teeth are in position and a denture is to be constructed supplying the posterior teeth, the present method of construction by connecting the two saddle portions of the plate upon which the artificial teeth are located, with the lingual bar, is far superior to the former method of extending the plate upon the lingual surfaces of the natural teeth. By means of the bar attachment a denture is constructed that is vastly more hygienic, interferes less with the movements of the tongue, and is free from the injurious effects to the gum and retentive structures of the teeth, so commonly observed in the other form of denture. (See Bridgework.)

Clasps.—Clasps are devices usually constructed of platinous gold (clasp metal) and adjusted to crowns of natural teeth to promote the retention of artificial dentures. The use of clasps is indicated when the means of plate retention, as previously considered, appear to be inadequate to sustain the plate satisfactorily, or when but few teeth are to be replaced, and this method of securing retention is concluded to be more desirable. When a clasp is adjusted to a natural crown, sooner or later a destructive effect upon the tooth may be observed. The greater opportunity provided for the collection of food débris and microörganisms when a clasp is adjusted to a tooth soon leads to lactic fermentation and the dissolution of the calcium salts of the enamel; the removal of the denture for cleansing purposes, and its movement under the stress of mastication, results in abrasion and in degeneration of the retentive structures, and finally in loss of the tooth; and while much depends upon the degree of accuracy secured in the adjustment of the clasp, and in the observance of correct principles of application, this but reduces the degree of

the ill effects noted, and does not entirely eliminate them.

The bicuspids are generally considered to be of most favorable form for the adjustment of clasps; the molars next, and the anterior teeth least favorable.

The clasp should always be formed of clasp metal, which is an alloy of gold and platinum, or of some other alloy possessing equal or greater advantages, and of a gauge assuring the necessary stability. For small dentures 26 gauge usually proves to be adequate, and for large dentures 24 gauge may be required.

Narrow clasps are not as desirable as wide ones. The retentive aid of the narrow clasp is not as good as

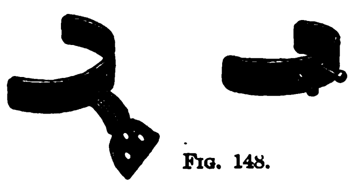


FIG. 148.

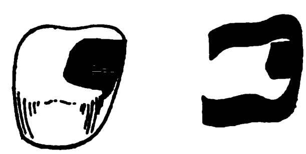


FIG. 149.

that rendered by the clasp adjusted to the widest part of the crown, and covering fully one-half its length. It is best to form a *fusible alloy model* upon which the preliminary adjustment may be made, after which the desired adaptation may be made directly upon the natural crown. When this has been satisfactorily attained, and if the artificial teeth are to be mounted upon a metal base, an impression should be taken with the plate and clasp in position, and the model poured with an investment compound, that the clasp may be attached to the plate without first removing plate and clasp and then investing them.

For vulcanite plates the clasp is provided with an extension that it may be securely anchored in the vul-

canite. Headed pins may also be used for this purpose. Fig. 148 illustrates the two forms.

The Bonwill Clasp.—The Bonwill clasp is the ordinary clasp with an extension soldered to it, which rests in a depression between the cusps of the tooth, so as not to interfere with the occlusion of the teeth. A better plan is to prepare a cavity in a suitable location which is filled with gold. A cavity is then cut into the gold filling, and into this the projecting piece of the clasp is fitted, and then attached to the clasp (Fig. 149).

Many practitioners, in order to avoid the injury to the tooth following the adjustment of a clasp, first prepare a shell crown for the natural tooth, and when this is in position the clasp is adjusted to the crown (see Bridgework).

CHAPTER XXVIII

DIES AND COUNTERDIES

When artificial teeth are to be mounted upon a swaged metallic plate, the formation of dies and counterdies are necessary preliminary steps toward the attainment of this result.

Preparation of Model.—In discussing the formation of the cast, in the preceding chapter, attention was directed to its shape when it was intended that it should serve as the model for the die, the greater area at its base than at its face, with its smooth sloping sides, being necessary for the proper formation of the mold. But these are not the only prerequisites of the model form. In forming the cast, which is to be the model for the die, it is also necessary that the planes of its base and face should be made parallel with each other; otherwise a model is formed that is not level. This uneven state will be reproduced in the die, and the attempt to swage the plate upon an uneven die is likely to impart a spring to it, very difficult to correct when formed. The desire to give the model sufficient depth. that the die may possess the necessary stability to withstand the blows of the swaging process, is not only unnecessary, but renders its removal from the sand more difficult owing to its increased depth. The die can be poured to any desired depth, irrespective of the size of the model, which, therefore, should not be increased beyond what is ordinarily required.

As almost all models present various undercuts, it is obvious that further preparation of the model is indicated, in order that a satisfactory mold may be produced. Many of these undercuts are located at such parts of the model that reproduction upon the die is not necessary; these should be filled up with wax, trimmed down to a perfectly smooth surface, and varnished. If the undercuts form necessary parts of the model, they should be enlarged by trimming down their border, but not deepening them. In this manner the undercut may often be satisfactorily reproduced upon the die without further effort. When this procedure cannot be successfully followed, some prosthetists recommend filling in the undercut with wax to the degree that will allow of a satisfactory mold to be made, and then cutting out the partially formed undercut upon the die until it is fully restored, when the counterdie is to be poured. This procedure, however, at best is inaccurate, and, while satisfactory results may be obtained thereby at times, it is usually safer to resort to the utilization of *cores* when it is found that the model cannot be successfully withdrawn from the sand, excepting, probably, by filling in the undercuts with wax.

The usual practice in forming the vacuum form upon the plate is to form a wax model of the chamber upon the cast; this is reproduced upon the die and appears in the plate when swaged. Dr. Wm. H. Trueman prefers the method of making a model of the chamber in copper or brass. "A piece of copper or brass of proper thickness is fitted by means of the bench hammer into the first die in the position of the desired chamber, held in place by a little adhesive wax, and swaged between die and counterdie. As this usually changes its position it should be sufficiently large to well cover the lines of

the chamber notwithstanding this, so that when it is shaped it will accurately fit the die in the position marked for it upon the cast. This is done on the first die and counterdie. It is then made the desired shape and size, and the edges are smoothly finished with a slight bevel. An expert workman has no difficulty in attaching this to the finishing die."

In those cases in which the rugæ are prominently formed in the mouth it is desirable to exaggerate their form upon the model by additions of wax. During the swaging process these are likely to be reduced in size, and, if the addition of wax has not been made, they are imperfectly reproduced upon the plate, and may be the means of preventing the successful retention of the plate, although skillfully constructed in every other way, as indicated in the discussion of plate retention.

The wax addition should also be made upon a lower model with a sharp alveolar ridge. If this is not done the sharp ridge is battered down in the swaging process, and the imperfect adaptation of the plate follows.

For partial cases it is best to trim down the plaster teeth within a short distance of the gum line, to facilitate the formation of the die and counterdie. When the natural forms of the teeth are allowed to remain upon the model, even though their shape may be favorable for easy withdrawal of the model from the sand, the disadvantages thereby arising are certainly to be observed in the subsequent process of swaging, therefore, the plaster teeth are to be trimmed down. The expert workman no doubt can produce a satisfactory plate when the entire tooth form is reproduced upon the die and the model preserved intact. But the general technique is thereby made more complicated and uncertain, and, as the simpler method requires but a second impression and the

formation of a second cast, this is to be preferred to the method of allowing the complete tooth form to remain upon the model, the uncertainty of a satisfactory mold, and the subsequent difficulties attending the method. Some prefer leaving the model intact and cutting down the teeth upon the die prior to the formation of the counterdie. While the teeth upon the zinc die can readily be cut down, if done while the metal is still hot, the method of cutting down the plaster teeth and then subsequently taking a second impression will be found to be generally satisfactory, with a saving of time over the former method.

When the model has been satisfactorily prepared a layer of sandarac varnish is applied over its entire surface, that a perfectly smooth surface may be produced, to which the molding sand shows little disposition to adhere.

The Mold.—Aside from the molding table and the few simple tools usually found adequate for the preparation of the mold, a *good molding sand* and a *suitable molding flask* are indispensable.

The Molding Sand.—Three varieties of sand are procurable, iron founders' *black sand,* brass founders' *brown sand,* and *marble dust.* At the present time marble dust is used almost to the exclusion of the other two varieties, not that it better meets the requirements of a molding sand, but because it can be worked more cleanly. A molding sand must be fine-grained that the metal of the die, when poured over it, may take a smooth surface. A further requisite is that, although finely grained, there shall be sufficient space between its particles to afford vent to the steam formed when the molten metal comes in contact with the water used in developing the adhesiveness of the particles of sand, necessary

to retain the form of the mold. Dr. H. H. Burchard[1] claimed to be able to obtain the best results with the brass founders' brown sand. More recently the dental depots have offered several secret compounds for obtaining the mold, for which superior qualities are claimed, and which appear to meet satisfactorily the requirements of a molding sand.

Fig. 150.—Bailey's Flask.

The Molding Flask.—The old Bailey flask introduced by Dr. E. N. Bailey[2] over half a century ago is still in general use. Later, more complicated devices have been introduced with the claim that by their use

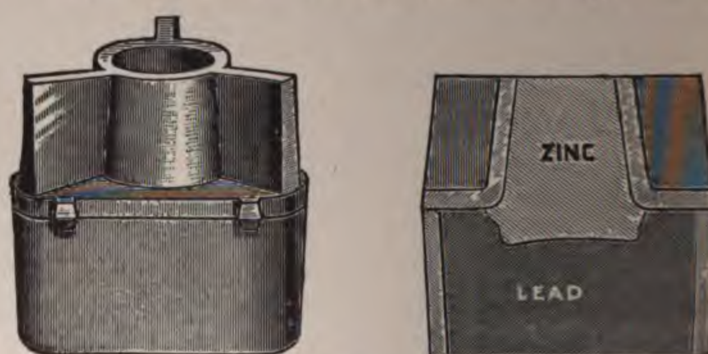


Fig. 151.—The Lewis Flask.

dies and counterdies can be formed that are more effective in swaging the plate. The Lewis and the Pearsall flasks are examples of this type of device (Figs. 151 and

[1] "American Textbook of Prosthetic Dentistry."
[2] *Ibid.*

152). The claim made for these flasks is not generally endorsed.

The Hawes sectional flask, introduced by George E. Hawes, is a device by the use of which a satisfactory mold can be obtained for those cases presenting deep undercuts, and for which it is exceedingly difficult to form a suitable die in the usual manner. The Hawes flask consists of a lower and upper section. In the lower section three flanges project toward the model. In these pieces of cardboard are placed to extend to the model,

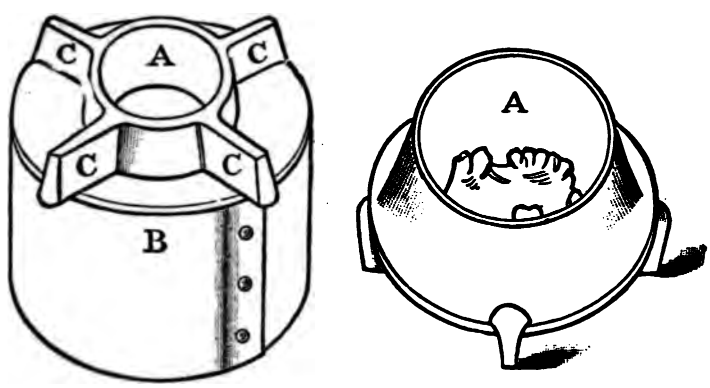
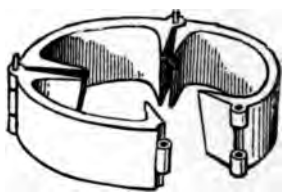


FIG. 152.—THE PEARSALL FLASK.

and which part the sand, after it has been packed about the model, that the model may be removed. The model should be set in the flask so that the alveolar ridge is about on a level with the upper edge of the flask. The sand is now packed as in the ordinary flask and smoothed down to a perfectly even surface. In the use of this flask the mold is also separated horizontally. Therefore, the edge of the sand next to the model should have sufficient thickness, and be so arranged that the separation of the mold takes place slightly below the prominent part of the ridge. The sand and model are next dusted with dry, pulverized charcoal, and the upper sec-

tion of the flask adjusted to position and filled with sand. When this has been done, the upper section is removed, the long pin holding the lower section together is withdrawn, the flask carefully opened, and the model withdrawn. The section is again closed, the pin replaced, the upper portion of the flask adjusted to position, and the device inverted when it is ready for the pouring of the metal. While this procedure is somewhat complicated, with care accurate dies may be obtained in very



Lower Half of Hawes' Flask.

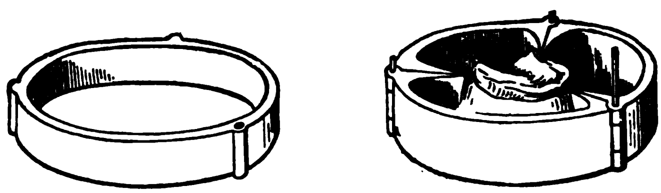


Fig. 153.—Hawes' Flask.

difficult cases of full dentures. Fig. 153 illustrates the device

Preparation of the Sand.—While the preparation of the sand to be used in obtaining the mold may appear to the inexperienced as an unimportant factor in the formation of a suitable die, the experienced workman regards it otherwise, and is assured that the condition of the sand is satisfactory before proceeding to form the mold. To determine the satisfactory state of the sand the following test is applied: A quantity of sand is taken in the hand and compressed by forcibly closing down upon it; this should fracture with a sharp line,

and still readily pass through the meshes of a fine flour sieve. A sand moistened sufficiently to show the sharp line of fracture, but not excessively to prevent its particles from readily passing through the meshes of a fine flour sieve, may be regarded as being in a satisfactory state for the preparation of the mold.

Ordinarily but little attention is paid to the condition of the sand in the molding box until the opportunity for its use arises. It is then moistened with water and passed through the sieve in the usual manner. A better plan [1] is to sift and moisten the sand immediately after it has been used, and to keep it in a moistened state by adding water each day. Treated in this manner, it is claimed [2] that the sand particles show greater cohesiveness, make a smoother mold, and are less likely to cause bubbling when the die is poured. If allowed to dry out the particles do not take up water readily, inducing the use of an excessive quantity, and still likely to form a rough mold. To prevent the evaporation of its moisture, the sand should be kept in a water-tight vessel, by which means its best working qualities are retained. The substitution of oil for water, which has been recommended, in order that the molding sand should always be in a suitable condition for use, has not been generally adopted. This agent imparts unclean working qualities to the sand, and when the molten metal is poured an exceedingly objectionable odor arises. The use of glycerin alone or combined with water has also been recommended, and is far less objectionable than oil; and while it is not as effective as oil in maintaining a satisfactory moistened state of the sand, it guards against the thorough dryness of the sand

[1] Dr. Trueman in "American Textbook of Prosthetic Dentistry."
[2] *Ibid.*

when water alone is admixed with it and allowed to evaporate.

Formation of the Mold.—When everything is in readiness, the model and sand having been prepared as desired, the model is placed within the flask, which should be sufficiently large to permit a half inch thickness of sand to be packed between it and all sides of the model. A quantity of sand is forcibly rubbed between the hands until the fine particles completely cover the model. This is pressed down firmly upon the face of the model, and between the model and flask. More sand is now added until the flask is filled, pressure being repeatedly applied to secure the desired compression of the sand. Just what the desired compression is cannot be defined. But the sand should not be packed too firmly, or the vapor generated by the molten metal in contact with the moistened sand cannot escape; hence, an imperfect die is likely to be formed. If not packed sufficiently firmly the mold is not likely to have a fine enough surface, the model will be inclined to "drag," or the sand may be displaced as the molten metal is poured upon it.

When the flask has been filled the surface may be leveled, and the flask inverted, the base of the model showing. A pointed instrument is next gently run around the model, removing a bevel of sand about one-quarter of an inch deep. All loosened sand is brushed away, and the instrument used to remove the sand, or any pointed instrument adapted for the purpose, is placed upon the center of the model, and with a hammer gently driven into the model, just far enough that there will be sufficient hold upon the model to admit of its removal from the sand. This must be done carefully, or the model in the act of removal may alter the cor-

rect lines of the mold. Many prosthetists prefer tapping the model by holding the flask in the hand, with the base of the model downward, then by gently tapping over the basal surface it is coaxed to leave the mold. The mold may now be carefully examined; if particles of sand have fallen into it these may be removed by moistening a finely pointed brush, and bringing the point of the brush in contact with the particles of sand, which will adhere to the point. It may also transpire that in removing the model from the sand small portions of the mold may come away with the model. After the model has been withdrawn the mold should be carefully examined for any portion that may have come away with the model. Frequently this can be replaced in position upon the mold, secured in place by adding a drop of water, and the die poured in the usual manner.

In some instances a satisfactory mold can be obtained by *tilting the model,* where otherwise the more complicated procedure of core-molding or the utilization of the Hawes flask would have to be resorted to. If upon trial, however, it is found that this expedient is not successful, the method of core-molding, or the use of the Hawes flask, must be adopted, as previously stated.

Core-molding.—By core-molding is implied the filling in of the undercuts upon the model by adding thereto a mix of plaster of paris (quick setting) in combination with pulverized pumice, marble dust, or any other substance that will enable the plaster to withstand, without fracture, the heat of the molten metal poured against the core. When the model has been varnished and dried, the combination intended for use is mixed and added to the model in the indicated region in sufficient bulk to admit of subsequent handling. This is smoothed and given a form that will admit of accurate replace-

ment in the sand prior to pouring the metal for the die. When the addition made to the model has sufficiently hardened, the mold is made in the usual manner, and when the model with the core in position is withdrawn from the sand, the core is separated and thoroughly dried. This is imperatively necessary to avoid bubbling, which, if it occurs, would most likely result in a faulty die. When the core has been thoroughly dried it is replaced in the mold and the die formed. Fig. 154 shows the model and form of the core.

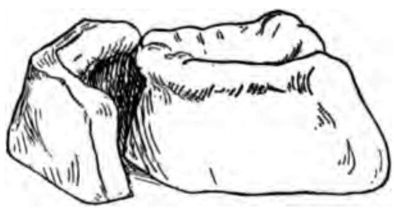


FIG. 154.—MODEL FOR UPPER JAW AND CORE.

In lower cases the presence of deep undercuts in the posterior lingual portion of the ridge may necessitate the use of a core for each side. The procedure is similar to that previously described, excepting, as stated, that two cores are utilized in place of one used in the former instances.

TILTING.—In place of cores satisfactory results at times may be obtained by preparing a mold and die for each half of the model; by *tilting* each half a satisfactory die may easily be obtained. The procedure is as follows: The model is separated two-thirds its thickness by means of a fine saw; the remaining one-third is fractured apart. The line of fracture subsequently enabling the accurate apposition of the two parts of the model. By *tilting* each half of the model, a satisfactory mold can usually be formed, and a die and counterdie made for each half. The plate is then swaged in two parts; when this has been satisfactorily accomplished the two halves of the model are accurately apposed, and secured in position with hard wax; the two parts of the

plate are then placed in position, trimmed, sustained in position by means of wax, invested, and soldered. This method of conforming the plate to the model is preferred by some prosthetists to the core method, which is a complicated procedure, and in many instances fails to yield satisfactory results.

Metals Used for Dies and Counterdies.—It is obvious that a metal, to serve the purpose of a satisfactory die, should possess certain attributes. These may be enumerated as follows: It should be sufficiently resistant to withstand the force of the swaging process; it should show no alteration of form through contraction or expansion; it should possess the necessary fluidity, when molten, to fill up all parts of the mold, and it should not require too high a heat to induce its fluid state. Of all the metals, or combination of metals, in general use for the production of the die, zinc and Babbitt metal possess these attributes in greatest degree. Some prefer a zinc die, others a Babbitt metal die. Good results unquestionably may be produced in the use of either the metal or the alloy. Dr. Wm. H. Trueman [1] writes as follows: "The writer, after several years' use of this alloy for the finishing die in cases retained by a vacuum chamber, abandoned it, finding it expensive and troublesome, and of no practical advantage." Dr. L. P. Haskell, on the other hand, advocates the following formula for Babbitt metal: copper, 1 part; antimony, 2 parts; tin, 8 parts, and claims that superior results may be obtained, providing it is intelligently utilized. He recommends that, when the alloy has been fused, it should be thoroughly stirred with a wooden paddle to guard against the separation of its constituent metals, which is likely to occur if this precaution is not taken.

[1] "American Textbook of Prosthetic Dentistry" (third edition).

The stirring should be continued until the molten mass shows a tendency toward setting, but is still sufficiently fluid for pouring, which should be done without hesitation. If these recommendations are not observed, the formed die is not likely to be satisfactory.

For the counterdie, when the die is formed of Babbitt metal, Dr. Haskell recommends an alloy of lead and tin, it being unsafe to use lead alone, as its fusing point is very close to that of Babbitt metal. Lead is generally employed for the formation of the counterdie when the die has been formed of zinc. It is a generally accepted fact among expert prosthetists that better results are obtained in the use of several counterdies formed of lead than by the effort to use but one, hardened by the addition of tin to the lead.

The introduction some years ago of a non-metallic compound known as Spence's metal, for which special advantages for die formation were claimed, soon proved to be unreliable, owing to its brittleness. As a finishing die it found favor in some quarters, but superior results may be obtained in the use of two zinc dies, and two or three lead counterdies. For the swaging of plates no metal or alloy up to the present time has displaced zinc or Babbitt metal for the formation of dies. These appear to share about equally the favor of prosthetists. There are many, on the other hand, who are guided by the condition of the tissues against which the plate is to be adapted, as to which metal is to be utilized in the construction of the die. These prefer the use of zinc for the die, when the tissue overlying the ridge and on either side of the hard median ridge admits of marked compression, the contraction of the zinc being favorable for the retention of the plate constructed for such cases; and the use of Babbitt metal for the die, for those cases

not presenting the soft tissue discernible in the former ones, but in place of which dense tissue is found, and for which the greatly lessened contraction of the Babbitt metal die would be more favorable. The low fusible alloys are especially indicated when a working model is desired, as in crown and bridgework, although at the present time the casting process has materially lessened the opportunities for their utilization.

Formation of the Die.—When the mold has been satisfactorily formed, as indicated, and in position upon the casting table, with the molding sand well packed against the casting ring to close any opening that might exist for the escape of the metal, the molten metal is ready for pouring. Prior to pouring it into the mold any oxid or foreign matter appearing upon the surface of the molten metal should be removed by means of an iron spoon. This not only prevents the formation of a rough surface upon the die, but allows somewhat for the cooling of the metal, which, if too hot, might cause the generation of an excessive amount of vapor, and the formation of an unsatisfactory die. It is also claimed [1] that poured, when somewhat cooled, its principal contraction occurs in the center of the die, which is advantageous. The metal is usually poured, in a steady manner, into one of the posterior depressions, being careful not to pour it from a height that would direct too forcible a stream against the sand and tend to loosen its particles, forming a rough surface upon the die, or making it unfit for use.

It is a good plan to form two dies, melting enough zinc at one time that the second die can be poured immediately following the pouring of the first. A second die is usually necessary, and, forming it at the time of

[1] "American Textbook of Prosthetic Dentistry."

the first die, conserves time. When the dies have somewhat cooled, they should be removed from the molding ring, and critically compared with the model. It is easier to make slight corrections upon the die before the metal has thoroughly cooled, and, when this has been satisfactorily done, the counterdie may be formed.

Formation of the Counterdie.—The die is placed within the casting ring and so arranged, by placing sand beneath it, that the face of the die slightly extends beyond the edge of the ring. This determines the distance the die will extend into the counterdie, and is usually somewhat greater for partial cases than for full dentures. If the die is excessively elevated in the ring it will be found, when the counterdie is formed, that only after the expenditure of considerable effort can the two be separated from each other, which is not only unnecessary, but may injure the counterdie and render it quite useless. In most instances a one-half inch extension of the die into the counterdie is sufficient. When the die has been satisfactorily elevated within the ring, molding sand is then firmly packed between the die and the casting ring until the edge of the ring has been reached. It is now smoothed down evenly, exposing only that portion of the die to be covered by the counterdie, and any sand particles found upon the face of the die should be removed. A second casting ring, large enough to allow the counterdie, when formed, to extend about one-half an inch around the die, is adjusted, with its larger end down.

The molten lead may now be poured over the die until the desired depth has been given the counterdie, and similar to the condition indicated, when discussing the pouring of zinc, it is best not to have the lead too hot when pouring it for the formation of the counter-

die. When the metal has cooled the die and counterdie are removed from the ring, and separated from each other. This is usually readily effected by a few blows against the die with the hammer, unless the lead has been poured too hot; or, in cases of undercuts, a little patience may be necessary to effect the separation without injury to the die.

CHAPTER XXIX

SWAGED METALLIC PLATES

Not alone has the casting process completely revolutionized the general technique of crown and bridgework, greatly simplifying the method of construction, and securing better adaptation and higher artistic effects, but its utilization has also brought about similar changes, in many instances, of partial plate construction. This is to be especially observed in comparing the present with the past method of restoring the inferior posterior teeth, the anterior teeth being in position.

Prior to the advent of the casting process in constructing a denture restoring the posterior teeth, it was necessary to form first the mold, then the die and counterdie, after which the plate was swaged to form, necessitating extension upon the lingual surfaces of the remaining anterior teeth, and the adjustment of the reinforcing plate, that the finished piece should possess adequate stability. This usually proved to be more or less destructive to the natural teeth, and while the present method of construction, in which the lingual bar attachment entirely eliminates the destructive effect usually observed when the plate is adapted to the lingual surfaces of the natural teeth, cannot be accredited to the casting process, the better adaptation of the saddles upon which the artificial teeth are mounted, and the su-

perior artistic results of the finished piece gained with far less expenditure of time, can only be secured in the utilization of the casting method in the construction of this form of denture. But as the casting process has not been as yet satisfactorily extended to the construction of full cases, excepting, perhaps, when aluminum is utilized for the base, and as partial cases may present for which it may be desirable to construct a swaged metallic plate, a consideration of the technique whereby this may be attained is in order.

When the dies and counterdies have been formed, as indicated in the preceding chapter, a pattern for cutting the metal for the plate must be prepared. It is important that this should be made to conform to the outlines prepared for the plate. If the pattern is not accurately formed, the difficulties of adapting the plate to the desired form will be increased; it being necessary, in some cases, to tear it before the desired conformation is obtained. The pattern may be made of paper, thin sheet lead, or tin foil. Some prefer the use of paper, claiming that when the pattern is finally prepared its subsequent distortion is impossible, whereas the use of either sheet lead or tin foil, while admitting of an easier formation of the desired shape, also admits of subsequent distortion, which disadvantage, in their estimation, more than balances the advantage. As a rule, the preparation of the pattern for a partial or full lower denture is more likely to be inaccurate than for upper cases. The greatest difficulty usually presents in lower partial cases in securing an accurate lingual adaptation of the pattern, or in the distortion which is so likely to take place in the pattern when it is flattened out. But, as previously stated, the advent of the casting process and the utilization of the lingual bar has completely

changed the method of constructing a denture for these cases, eliminating the necessity for the formation of a pattern.

When the pattern has been formed it is placed upon the sheet of gold and with a sharp instrument its outlines are marked thereon, allowing about 1/16 of an inch surplus upon all sides. For an upper plate 26 gauge usually will be found to be sufficiently rigid; this may be reinforced by a piece of 28 gauge in exceptional cases, where great stiffness is indicated. This is preferable to the use of a single thickness of 24 gauge, which is decidedly more difficult to swage, and not as rigid as the two pieces soldered together. For lower cases the use of two pieces of 29 or 30 gauge materially lessens the difficulties compared to swaging a heavier plate, and when soldered together furnish the desirable stiffness; furthermore, the capacity of the die to withstand the blows necessary to swage the heavier plate must also be considered as a factor determining the use of two layers of thinner gold.

Swaging the Plate.—When the metal has been cut to form, and before proceeding with the swaging process, it should be annealed by exposing it to heat until its entire surface shows a "cherry" color. If too much heat is applied fusion of its surface will occur, which renders the plate unyielding and brittle and likely to split apart in the swaging process. When the plate has been heated to the color previously indicated, it may be quickly cooled by dipping it in cold water, after which it is placed upon the die, and with a horn or wooden mallet its outer edge is bent over the ridge. Care should be taken that the edge of the plate extends slightly beyond the outline of the plate prepared upon the cast, as in the swaging process the plate is forced into

the vault, and if this allowance beyond the outline is not made the plate will not conform to the outline prepared upon the cast. The procedure of first bending the plate over the ridge before adapting its central portion to the die is also decidedly advantageous in subsequently holding the plate in position when the adaptation to the vault is made, during which effort the plate shows a strong tendency to move backward. This backward tendency of the plate, at this stage of the adaptation, is obviously in a great measure controlled if the edge is first bent over the ridge. It will also be noted that in proceeding with the adaptation of the plate, as indicated, the "buckling" of the rim is avoided, which, on the other hand, is likely to occur if the attempt to conform the plate to the vault is made before bending the portion over the ridge. But little experience is needed to determine the advantages and disadvantages of one or the other method.

So, too, is it quite obvious that it is advantageous to secure a fair degree of adaptation of the plate to the die with the mallet before using the counterdie. This applies especially to the region of the vault. If the counterdie is used before the plate has been drawn well down upon the die in the indicated area, it will be exceedingly difficult to effect the desired adaptation after this, because the plate has been swaged into close contact with the ridge and resists closer adaptation to the vault. The palatal portion of the plate may be adapted to the die by swaging down with partial counterdies, several of which are required, the first one only covering the central area of the palate, the next a larger area, and so on, until the ridge is reached. When the plate has been as closely adapted to the die with the mallet or with the partial counterdies as may appear desirable,

the counterdie may be used for securing the final adaptation.

This is accomplished by placing the plate upon the die, adjusting the counterdie to position, inverting, so that the counterdie rests upon the anvil or wooden block upon which the swaging is done, and holding the die firmly in position a gentle blow is first delivered, which forces the die and counterdie into closer relation with each other. It is well at this stage to examine the position of the plate; if it has not moved several firm and well-directed blows should be delivered. Previous to placing the plate upon the die two or three thicknesses of paper or muslin are placed upon the die; a similar covering should be prepared for the plate before the counterdie is adjusted; this not only protects the plate from small particles of zinc and lead that might adhere to its surface, and which during the annealing process would be likely to combine with the gold, forming an alloy, fusing, and forming a perforation in the plate, but it also aids in removing the plate from the counterdie after it has been swaged. While ordinarily the protection afforded the plate by placing it with the paper or cloth, as suggested, safeguards it against the deposit of zinc or lead upon its surface, nevertheless it is a safer plan to place the plate within the sulphuric acid solution prior to annealing it. This assuredly removes all base metal, and prevents the perforation of the gold plate, which, as previously indicated, would be likely to take place if the base metals were not removed.

After forcing the die into the counterdie with several firm and well-directed blows, the die is removed and the form of the plate carefully observed. Any disposition to "buckling" should at once be corrected. If the plate

is not in contact with the palatal portion of the die, as previously noted, it should be malleted to the desired adaptation before proceeding with the swaging process. The extension of the plate beyond the outlines indicated upon the cast should be corrected, although care must be exercised that excessive trimming should be avoided, and allowance should be made for any "shortening" that further swaging may produce.

In many cases it is necessary to remove a V-shaped piece from the plate in the region of the frænum. It is a good plan to defer the removal of this section until the alveolar outline of the plate is finally adapted to the cast. After the plate has been swaged it will be found that its alveolar edge is somewhat larger than the outline upon the cast. By removing the section of plate in the region of the frænum and apposing the edges the surplus is taken in, and a desirable adaptation along the alveolar edge is secured.

Forming the Vacuum-Chamber.—The usual practice is to reproduce the wax chamber form of the cast upon the die, and later upon the plate through the swaging process. When the plate has been swaged the chamber form is more sharply defined by placing the plate upon the die, and by means of a chaser and a few light blows the plate is driven closer to the die. Most prosthetists, however, prefer to cut out the vacuum form upon the plate, not completely until after the desired adaptation of the plate has been secured. Then the edges of the vacuum form upon the plate are trimmed down to the outline upon the die. A piece of plate somewhat larger than the vacuum form is swaged and trimmed down to extend about 1/16 of an inch beyond the edge of the form, cut out upon the plate. The swaged chamber form to be soldered to the plate may be formed to ex-

tend to the posterior edge of the plate (Fig. 155). This is advantageous in those cases presenting a hard median ridge, and where it may be necessary to trim down the inner surface of the plate to relieve the pressure upon the median ridge. The extension of the vacuum piece to the posterior edge of the plate provides a double thickness of plate in this region, and admits of trimming down from the palatal surface, when this is necessary without weakening the plate. The extension may also be made toward the tuberosities to provide additional resistance, if this should be required, in this region.

FIG. 155.—VACUUM PIECE EXTENDING TO THE POSTERIOR EDGE OF PLATE. (Burchard.)

In Chapter XXVII attention was directed to the method of forming the vacuum chamber by preparing a copper or brass model for the die, as recommended by Dr. Wm. H. Trueman. When the copper form has been attached to the die, and a depression swaged into the counterdie, the means of swaging a piece of gold plate into the vacuum form has been provided, which may then be fitted to the plate, as previously indicated. The chief advantage of this method is that the model for the mold is without the wax chamber form, which is advantageous for the preparation of the mold.

When the alveolar edge of the plate has been satisfactorily adapted, including that portion in contact with the frænum, and the vacuum piece swaged, the plate and vacuum piece are placed upon the finishing die, the counterdie adjusted, and the final swaging given the

plate. The split in the region of the frænum may now be soldered.

The Adaptation of the Plate.—Many prosthetists, at this stage of the procedure, and with the vacuum chamber waxed in position, determine whether a desirable adaptation has been secured by placing the plate upon the cast, carefully observing it, also by applying certain tests, which, if satisfactorily responded to, determine the desirable state of the adaptation. In adjusting the plate to the model it should not scrape the alveolar portion of the cast in going to place. If the plate cannot be adjusted to its position upon the cast without scraping it, its edge must be bent outwardly, just enough to avoid this. If this is not done the plate will be held securely in position upon the cast and other defects will not be observed. This is especially so in regard to "rocking." A plate that is firmly held by its edge cutting into the alveolar portion of the cast will not respond to the tests applied to determine whether it "rocks" or not, and, as this is an important determination, the edge of the plate must be bent slightly outward that it may go to place upon the cast. Pressure is now applied upon the ridge, first on one side, then upon the other; also upon the anterior region of the ridge, and at the posterior edge of the plate. No movement of the plate should be discernible under the pressure applied at these various parts of its surface. If, however, any movement can be detected, the cause of this should be ascertained, and the effort made to remove it. If the tuberosities are prominent and well rounded the edge of the plate may not easily pass over them, preventing the plate from going to position. The plate may unduly touch some portion of the median hard ridge, which may have been flattened down in the process of swag-

ing, or an imperfect die may have been formed. At times sufficient alteration may be made in the form of the plate by striking it a few light blows with the mallet while in position upon the cast, or by placing several layers of paper or tin foil upon the die, in the location where relief from undue pressure is desired, and reswaging the plate. If these efforts fail to afford a satisfactory adaptation new dies and counterdies should be formed.

When a satisfactory adaptation of the plate to the cast has been secured it is ready for trial in the mouth. No matter how perfectly the plate may fit the cast, it should not be completed without trial in the mouth. The action of the muscles in the region of the bicuspid teeth, or the posterior edge of the plate, the imperfect reproduction of the rugæ, may be factors of imperfect adaptation, or additional changes may be required owing to the presence of markedly soft tissue, and without trial in the mouth the facts one way or the other cannot be ascertained. The writers believe that prior to the trial of the plate in the mouth the vacuum piece should be attached at one point with a minute quantity of solder. If, subsequently, it should be necessary to reswage the plate, the vacuum piece may easily be detached. If this is not done most likely the vacuum piece will be detached in the act of drawing the plate into position.

The plate is now adjusted to the mouth, and if its edge presses too hard into the soft tissues this should be corrected by bending it outward. Next pressure is made to determine if the plate "rocks." As a rule, this is due to excessive contact with the hard median ridge, the remedy for which lies in placing several thicknesses of tin foil over the ridge upon the die and reswaging the plate. The effect of the movement of the muscles

of the soft palate, also that found in the region of the bicuspids, next should be noted. If the outline of the plate has been incorrectly formed the movements of these muscles will displace it. In these cases the posterior edge of the plate or that in contact with the buccinator muscle must be trimmed down. If these expedients fail to establish a desirable adaptation it is better to begin anew by taking an impression and carefully proceeding according to the methods previously discussed.

In partial upper cases, if the adaptation of the plate to the remaining natural teeth is at fault, the desired adaptation cannot be attained. In many cases the final fitting of the plate must be done in the mouth, and the plate bent with pliers, that the correct adaptation may be secured. The retention of full lower plates, as previously stated, depends upon their weight and adhesion. The former factor is satisfactorily realized in the type of denture under consideration; its adhesion depends upon the form of the plate, and the accuracy of the various steps in the procedure. When the plate is placed in the mouth for trial it will usually be found that almost the entire lingual edge, excepting, perhaps, that in the bicuspid region, requires bending inward. The reader is referred to the chapter dealing with the outline of full lower plates for the details of form. While it is desirable to provide as much contact of surface as possible, the movable tissues must be avoided.

In partial lower dentures, while a close observance of the same general principles unquestionably obtains, the type of denture constructed for these cases at the present time, as previously noted, in many cases is upon entirely different lines, eliminating almost all the former difficulty of obtaining satisfactory adaptation; but

where it is necessary to construct the denture upon former lines, the adaptation of the plate to the soft tissues and to the remaining natural teeth, the necessary reinforcement of the plate, and the method of obtaining desirable retention must all be effectively carried out if a successful denture is to be constructed.

Soldering the Vacuum-Chamber.—Previously it has been stated that when the plate is ready for trial in the mouth the chamber piece is attached to the plate at one point with a minute quantity of solder. When this has been done hard wax is flowed over the joint between the metal of the vacuum chamber and the plate, and the annoyance of having the chamber piece detached during the trial of the plate is avoided. The usual method of holding the chamber piece in position by means of iron clamps during the soldering process, as shown in Fig. 155, is an unnecessary effort, retarding the fusing of the solder and incurring the possible risk of distorting the form of the plate. The chamber piece may readily be attached to the plate preparatory to the trial in the mouth by placing the plate upon the soldering block with the chamber piece adjusted to position. The gradual heating of the plate will effectively retain the chamber piece in position, after which a minute quantity of solder carrying a little borax is placed in position, heat applied, and the attachment made to the plate. If it should be necessary to subsequently remove the chamber piece, this can readily be done by applying heat to the minute soldered portion. If, on the other hand, the plate upon trial is found to be satisfactory, the remaining portion of the inner side of the joint is touched with borax, several pieces of solder placed in position upon the outside, heat applied, and the joint closed, the solder flowing toward the borax. When completed the plate

is placed in the acid bath, and when thoroughly cleansed is washed in water, dried, and placed upon the cast. As a rule, the adaptation will now be as satisfactory as it was preliminary to the soldering. The edges of the plate are now dressed down with sand paper, and, when completed, the plate is ready for trial in the mouth.

Swaging Full Lower Plates.—In conforming the metal for a full lower plate to the die, after it is annealed, it should be bent over by means of the bending pliers (Fig. 156) to a saddle form to rest upon the inferior ridge, in the continued effort to conform the metal to the outlines of the die. The bending of the plate, preliminary to subjecting it to the blows of the mallet, in cases with a sharp and deep ridge, is especially advantageous, as the danger of battering down the ridge by excessive malleting is thus avoided. As previously stated, as a rule, better results are obtained when two thicknesses of 30 gauge metal are separately swaged to form and soldered together than the use of one thickness of 24 gauge for a lower denture. It is with much less difficulty that the thinner metal is conformed to the die, and when the two plates are soldered together a very rigid plate is formed. The 24 gauge, on the other hand, is very difficult to conform to the die, and when finally formed is more easily bent than the plate in the former instance. When the two plates are constructed the upper one should be trimmed a little short of the underneath plate, that a resting place may

FIG. 156.

be provided for the solder used in uniting the two plates. Prior to soldering the two plates it is well to swage them together, first placing a thickness of paper upon the die, also adjusting a thickness upon the plates when in position upon the die that the metal should not come in direct contact with the zinc or lead and require the acid bath, as previously indicated, for the removal of the baser metals, which is necessary prior to annealing or soldering. The two plates may be held together with binding wire to guard against separation during the soldering process, but this is unnecessary if the procedure here is followed, as indicated in discussing the "soldering of the vacuum chamber," and the risk of bending the edges of the plate from the force of the wire may be avoided. The other steps in the procedure are similar to those discussed in considering full upper plates.

Partial Lower Plates.—Swaged partial lower cases, as previously stated, are the exceptions now in practice, so seldom are they formed. The casting process and the lingual bar attachment have brought about this change. By referring to the chapter on Bridgework, the many advantages accruing from the use of the present type of denture are discussed. The reader is also referred to this chapter for the descriptive details of this character of operation.

Wiring Plates.—In constructing a gold plate with a rubber attachment, in place of allowing the vulcanite to finish off to the plate, along the edges of the plate or upon the palatal surface of superior plates, superior results are obtained if an 18 gauge gold wire is attached to the plate and the vulcanite finished off to this. Not only is a higher artistic effect attained in the finished piece, but the subsequent contraction of the vulcanite,

which is usually followed by the formation of a space between the vulcanite and metal, is thereby avoided, the plate so finished being superior in hygienic requirements, as the space for the ingress of food débris and microörganisms is wanting, and, furthermore, the rubber is held more securely to the plate (Fig. 157).

In attaching the wire to the plate a piece sufficiently large to meet the requirements is selected and annealed. It is then adapted to the edge of the plate while the plate is upon the soldering block, and heat is carefully applied so as not to disturb the relation of the wire. By means of the heat the wire is held in position, providing no great force is allowed to displace it, when a minute quantity of solder touched to a creamy solution of borax is gently placed in position, and the attachment at this point made permanent. The plate is allowed to cool and the wire more perfectly adapted to the plate, according to the requirements of the case. Additional pieces of solder are placed along the joint, formed between wire and plate, and the attachment completed.

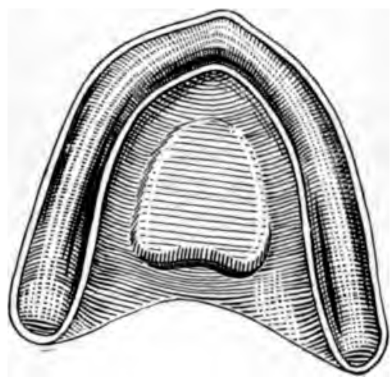


Fig. 157.—Upper Plate Wired for Rubber Attachment.

CHAPTER XXX

THE BITE—THE SELECTION AND ADAPTATION OF ARTIFICIAL TEETH

The principles underlying the "taking of the bite," that the artificial teeth may be selected and adapted to best serve the purposes of mastication, speech, the restoration of facial contour, and the esthetic effect of artificial dentures, have been completely developed only in recent years.

In reviewing the knowledge related to this department of prosthodontia from the time of Bonwill to the researches of Gysi, published in the *Cosmos,* 1910, it is quite evident that up to within comparatively a few years ago all efforts to correctly articulate artificial teeth were founded upon such deficient knowledge that wonder arises that the results obtained prior to the development which has taken place in recent years were as satisfactory as they appeared to be.

While the fruition of Dr. Bonwill's labors appeared in the presentation of his "anatomical articulator," and although this instrument was superior to the articulators in use at the time—and, regretfully is it said, at the present time as well—which only admit of the up-and-down movement, nevertheless, the Bonwill instrument never came into general use because, while the teeth in *occlusion* outside of the mouth were perfectly antagonized, in *articulation* in the mouth they were but little better than the dentures antagonized upon the ordinary

articulator which only admits of the up-and-down movement.

The terms *occlusion* and *articulation* require definition, that the confusion frequently arising from their synonymous use might be avoided. Years ago Dr. Bonwill differentiated between these two terms in the following manner: "Articulation is a word of action throughout, while occlusion answers to the mere act of closing the teeth and lips and keeping them closed; one is active, the other passive." In occlusion but one relation exists between the antagonizing teeth. In articulation various relations exist.

When artificial dentures are constructed to accurately represent the normal movements of the natural teeth they are said to be "anatomically articulated." As previously stated, Dr. Bonwill was probably the first investigator in the field of endeavor to attempt to reproduce the movements of the natural teeth in artificial dentures, and the fruition of his researches and genius appeared in the presentation of his "anatomical articulator." This instrument, although superior to those in use at the time of its presentation to the profession, failed of general adoption because it was soon recognized that, while the teeth occluded and articulated perfectly upon the articulator, they did not do so when the dentures were placed in the mouth—i. e., they occluded as perfectly in the mouth, but they did not articulate perfectly.

The cause of this defect remained unknown until Dr. W. E. Walker, in a paper before the Southern Dental Association, November, 1895, called attention to his discovery of the slant in the roof of the glenoid fossa with which the condyle articulates. Therefore, in the forward and lateral movements of the mandible, the condyle not

only moves *forward,* but *downward* as well. Dr. Walker speaks of his discovery as follows: "The angle in Dr. Bonwill's articulator which controls the representation of the movement of the condyle in the glenoid fossa forms a right angle to the portion representing the ramus, thus reproducing the *horizontally forward* movement of the condyle which we have been taught. After much study and experimentation I found that to reproduce the correct articulation of the casts of natural teeth in the various positions of the jaw, with all the normal points of contact of the cusps, it was necessary to increase this angle until, for the average jaw, it reached an increase of thirty-five degrees on a Bonwill articulator thus remodeled."

The *downward* movement of the condyle had been noted previous to Dr. Walker's observations by two anatomists, Luce of Boston (1899), and Count Spee (1890). But the practical application of this fact to the articulation of artificial teeth rightfully belongs to Dr. Walker, and his modification of the Bonwill articulator, which he called the Bonwill-Walker articulator, was the first instrument introduced to the profession capable of representing the downward movement of the condyle. Recognizing the importance of measuring the individual inclination of the condyle path in order to accurately reproduce the movements of the teeth in each case, Dr. Walker also devised an instrument which he called the "facial clinometer," whereby this could be done, but as both the articulator and the measuring apparatus were exceedingly complex these devices were not generally adopted by the profession.

But the correctness of Dr. Walker's contentions induced others to devise articulators less complex than the Bonwill-Walker. Of these the Gritman articulator

(Fig. 158), introduced shortly after the appearance of the Bonwill-Walker, is still in use, and, while it is incapable of being adjusted to the individual condylar inclination, it has an average condyle slant provided by a fixed slotted plate. For the average case the instrument devised by Dr. Gritman subserves a most excellent purpose. Schwarze (1900) and Christensen (1902) and others presented devices capable of a downward movement, the necessity for which as a fundamen-

FIG. 158.—THE GRITMAN ARTICULATOR.

tal principle in the articulation of artificial teeth was now well recognized.

Dr. Christensen also presented a very simple method for determining the condylar inclination, and, while the method may not give the accurate registration obtainable by the utilization of the later device of Gysi (*Cosmos*, January, 1910), it nevertheless is capable of yielding satisfactory results without the use of a special apparatus.

Dr. Christensen's method consists in taking the bite in the ordinary way and transferring the casts and bite plates to the articulator. Softened wax is then added to the posterior portion of the bite plates, and the bite again taken with the mandible in a protruding position.

These are again placed upon the articulator, the joint of which is adjusted to follow the protruding movement, thus fixing the slant of the condyle path. Dr. Gysi claims (*Cosmos,* January, 1910) that in this method, as well as that of Walker's, accurate results are only obtained when the condyle path forms a straight line and not

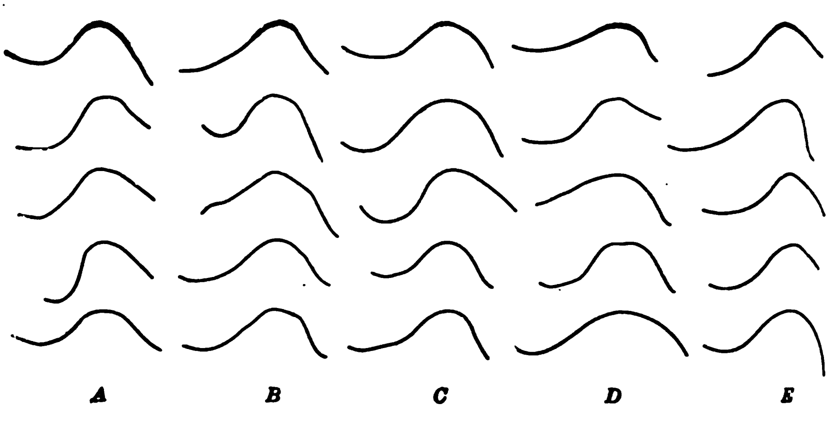


FIG. 159.—OUTLINES OF GLENOID FOSSÆ OBTAINED BY THE METHOD OF TOMES AND DOLAMORE.

The heavy base line is parallel to a line drawn from the anterior nasal spine to the floor of the external auditory meatus. All the fossæ outlined were on the left side of the skull. A, from skulls with typical dentures; B and C from skulls with several teeth missing; D and E from edentulous skulls. ("American Textbook of Prosthetic Dentistry.")

the usual curve, or S-shaped curve generally recorded by the measuring instruments.

Fig. 159 illustrates the outlines of glenoid fossæ obtained by the method of Tomes and Dolamore, whose studies on mandibular movements were published in 1901.

Fig. 160 illustrates the four average forms of condyle paths as registered in edentulous patients by Gysi.

Several years later Dr. Snow introduced his latest articulator, called "the new century articulator," also his "face bow and plate guides." This articulator closely

resembles the Gritman, but has an adjustment whereby the individual condyle slant can be reproduced. The "face bow" regulates the distance the models should be placed upon the articulator to be in correct relation with the condyle joint, and is of the greatest importance in determining the reproduction of the normal movements of the teeth.

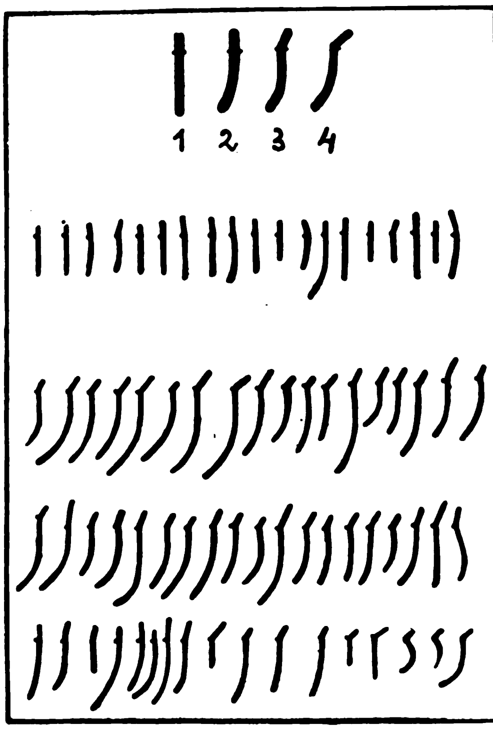


FIG. 160.—THE FOUR AVERAGE FORMS OF CONDYLE PATHS. (Gysi.)

Since then Dr. Gysi has presented his researches in articulation (*Cosmos,* 1910); also, his articulator and face bow arrangements, and both of these devices represent the highest form of instruments measured in terms of exactness and efficiency in relation to the reproduction of the normal movements of the natural teeth in artificial substitutes.

In all instruments intended for articulating artificial teeth introduced since Dr. Walker presented his researches, the feature is present of obtaining the reproduction in the drop of the ramus owing to the inclination in the roof of the glenoid fossa over which the con-

dyle travels, in the forward and lateral movements of the mandible. In some the condylar inclination is invariable and fixed at the average angle. In others the inclination can be adjusted to the individual case, after the movement of the condyle has been obtained by spe-

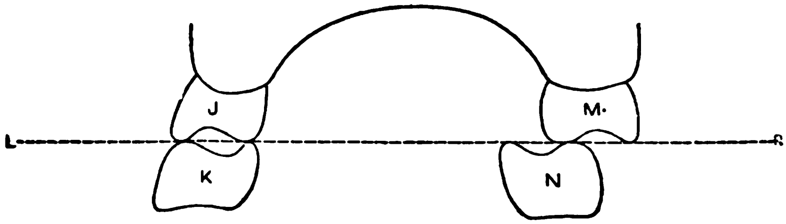


Fig. 161.

cially prepared instruments; and while the utilization of the articulator with the adjustable condylar inclination is somewhat complicated, exactness justifies the expenditure of the additional effort. But in no instance can even an approach to the normal movements of the teeth be obtained in artificial dentures when articulated upon

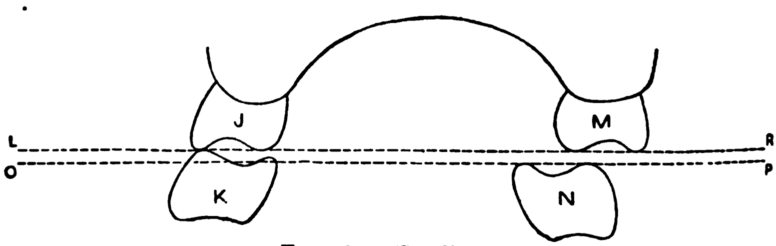


Fig. 162. (Dr. Walker.)

instruments in which the drop in that portion represented by the ramus cannot be obtained. The following illustrations[1] will make this clear.

Fig. 161 represents the molars upon one side in the

[1] This illustration is the familiar one used by Dr. Bonwill and shows the molars with the cusps of the same elevation, which is necessary when the teeth are articulated in the Bonwill articulator, but is a condition rarely found in the mouth.

masticating position with the lingual and buccal cusps in contact, and the molars upon the other side in the balancing position, the outer cusp of the lower molar being in contact with the inner cusp of the upper molar. Teeth articulated upon the Bonwill articulator will take the position shown in the illustration when the jaw of the articulator is moved laterally. But when these teeth are placed in the mouth, the downward movement of the condyle in the lateral excursions of the teeth, for which no provision has been made upon the articulator, will cause the teeth to be in the condition illustrated in Fig. 162.

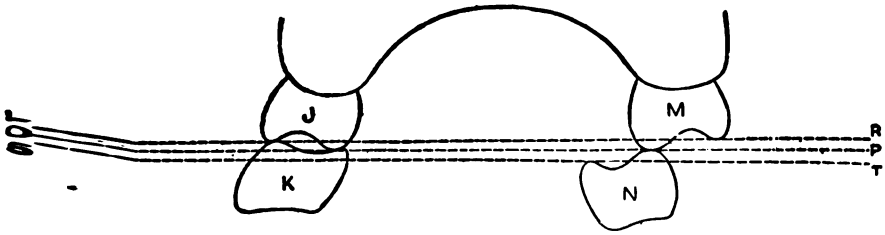


FIG. 163. (Dr. Walker.)

Fig. 163 represents the molars with normal cusps anatomically articulated in the same movement of the mandible as shown above, the line L R representing the plane of the short buccal cusps of the superior molars J and M. The normally longer lingual cusps are marked by the line O P. With the same movement of the mandible the denture is balanced by the long buccal cusp of the lower molar N, meeting the long lingual cusp of the superior molar M. Upon the other side the contact is also perfectly established, the long lingual cusp of the superior molar J being in contact with the short lingual cusp of the inferior molar K upon the plane O P, and the long buccal cusp of the inferior molar being in contact with the short buccal cusp of the superior molar upon the upper plane L R.

Fig. 164 is a diagrammatic illustration by Dr. Walker of the relative height of the buccal and lingual cusps of the bicuspids and molars. C G represents the plane of the buccal cusps, E F the plane of the lingual cusps. These lines are here represented as being straight, the illustration being diagrammatic. In the mouth these lines would follow the curve of the line of occlusion. The intention here is simply to indicate the relative differences of the cusps. The illustration plainly indi-

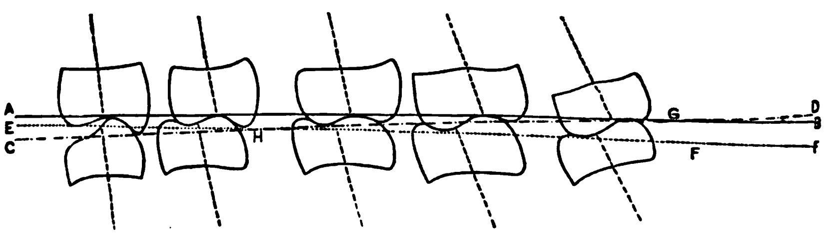


FIG. 164.—DIAGRAMMATIC VIEW OF THE RELATIVE HEIGHT OF THE BUCCAL AND LINGUAL CUSPS OF THE MOLAR AND BICUSPID TEETH. (Walker.)

cates the gradual diminution in the size of the buccal cusps of the superior teeth as we proceed distally, whereas the lingual cusps increase in length as we proceed toward the distal end of the arch. If the condyle, in the lateral movements of the mandible, did not move downward, owing to the slant in the roof of the glenoid fossa previously indicated, causing the downward movement of the posterior portion of the jaw, interference of the cusps would inevitably take place, and mastication could not be normally performed. Furthermore, as the angle of the slant in the roof of the glenoid fossa varies considerably in different subjects, it is necessary for exactness that the articulator should be adjusted to each case, and to do this it must be provided with a variable angle.

Important as are the preceding facts in relation to

anatomical articulation, they will avail nothing if the models are not placed upon the articulator in correct relation to the joints. This can only be accomplished by the use of the "face bow." The average distance from the condyle to the mesial angle of the inferior central incisor is 4 inches; it varies in many cases from 3⅝ to 4⅞ inches.[1] If the models are not set upon the articulator at the proper distance from the joint, when the dentures are placed in the mouth the condition in-

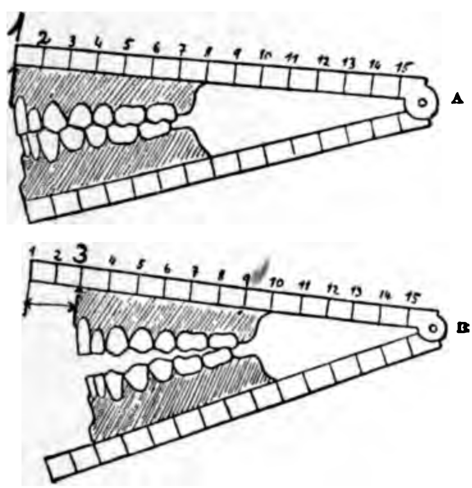


FIG. 165.

dicated in the following illustration is likely to take place (Fig. 165). The upper models in the illustration are set upon the articulator with an abnormal incisor-to-condyle distance and the teeth articulated. The lower illustration shows the dentures when placed in the mouth, with the posterior teeth only in occlusion. Or the reverse of this condition may obtain if the models are set upon the articulator too close to the condyles, only the incisors will be in occlusion, and the articula-

[1] Dr. G. W. Clapp.

tion of the dentures will be a failure even though otherwise correctly articulated.

Before proceeding with the discussion of the "bite" and the method pursued to accurately fix the models and bite plates upon the articulator, it will be advantageous to consider "anatomical articulation" and what takes place in the different movements of the mandible.

FIG. 166. ("American Textbook of Prosthetic Dentistry.")

"Anatomical articulation" has been previously defined as the accurate reproduction of the movements of the natural teeth in artificial dentures. Figs. 166 and 167 show both the buccal and lingual view of perfect occlusion. In the following illustration (Fig. 168) is shown the lateral movement of the mandible. The black line in the incisor region shows the distance of the move-

ment. In the comminution of food the mandible moves downward upon one side, creating a space into which the food is forced by the action of the tongue and cheek. In the upward movement the buccal cusps of the inferior teeth, upon the side engaged in crushing the food, interdigitate with those of the superior teeth, and are almost in the same vertical plane. The mandible then

FIG. 167. ("American Textbook of Prosthetic Dentistry.")

moves toward the median line, the cusps of the posterior teeth passing through grooves or spaces between the cusps of the antagonizing teeth.

Upon the other side, in the downward and lateral movement of the mandible, the inferior third molar has moved forward and inward. Fig. 169 shows the position of the tooth with its buccal cusps in contact with the lingual cusp of the superior second molar. The im-

portance of the contact of the third molar with the sec- ond may be fully realized when it is considered that in the stress necessary at times to crush the food the man- dible would be in danger of being twisted, if it were not for this contact upon the side opposite to which the

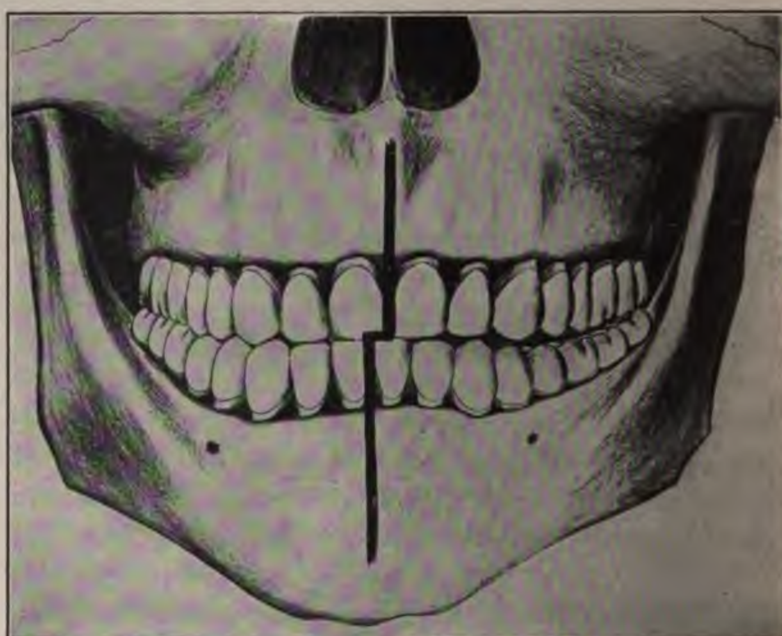


FIG. 168.—DIAGRAMMATIC ILLUSTRATION SHOWING THE LATERAL MOVEMENT OF THE MANDIBLE.

The mandible has moved downward, sideways and upward, and is now ready to begin the final crushing movement. The buccal cusps of the bicuspids and molars on the right side are in the same vertical plane and interdigitated. The final crushing movement will be accomplished by the sliding of the mandible back to a position of occlusion. This distance is shown by the offset in the vertical line. (Dr. Clapp by Courtesy of Dr. W. J. Brady.)

crushing stress is applied. In the arrangement of artificial teeth a similar contact must be provided; otherwise it is quite obvious the plate cannot be sustained in position in the lateral movements of the mandible.

The cutting of the food is accomplished by the in-

cisors. In this act the mandible moves forward and downward, i. e., the mandible is protruded, the degree of which varies not only in the individual case, but in different individuals as well. Or the incisive edges of the superior and inferior teeth may be opposed and the cutting act completed as the inferior incisors move backward and upward against the lingual surfaces of the

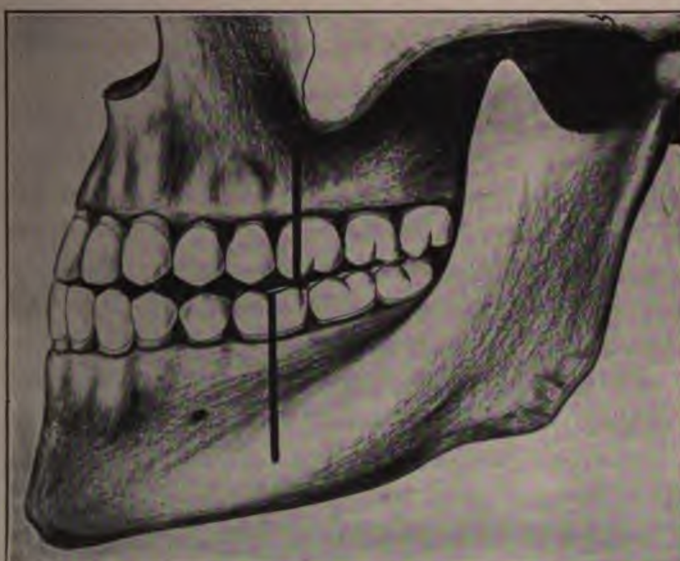


FIG. 169.—DIAGRAM ILLUSTRATING THE FORWARD MOVEMENT OF THE MANDIBLE TO PRODUCE THE END TO END BITE.
When the mandible is in central occlusion, the vertical black line is continuous. (Dr. Clapp by Courtesy of Dr. W. J. Brady.)

superior teeth, as the cusps of the posterior teeth move upon the inclined planes of the antagonizing teeth into the position of occlusion. When the incisor teeth are separated there is no contact between the posterior teeth. As the incisive edges come together the mandible moves forward, in many cases at least about half the mesio-distal width of a bicuspid,[1] and complete contact

[1] Dr. G. W. Clapp, "Anatomical Articulation."

of the posterior teeth is established. But the contact so established between the posterior teeth is different from that established in the crushing movement. The buccal cusp of the superior first bicuspid is now in direct contact with the buccal cusp of the inferior second bicuspid and the mandible is in extreme protrusion. The contact just described is established by the antero-posterior curve of the occlusal surfaces, known as the Compensating Curve or the Curve of Spee [1]

Dr. George W. Clapp, in his "The Mechanical Side of Anatomical Articulation," writes as follows concerning the above movements of the natural teeth:

"We see, first, that in the position of direct occlusion and that of lateral occlusion the teeth interdigitate with almost the accuracy of year teeth. We see also that in all positions where great force is to be exerted the mandible lies in contact with the upper denture at three or more widely separated points. By thus supporting the mandible against tipping, it is possible for the temporal and masseter muscles *of both sides* to exert their power in the final biting or shearing movement, and in the final crushing movement. The power of the jaw is thus greatly increased over that which would result from the pull of only one set of these muscles.

"Great as are the advantages of these mechanical arrangements to the natural denture, those resulting from similar articulation of artificial dentures are greater. The teeth of the natural denture cannot be easily dislodged, but if the artificial dentures are poorly articulated they may be so easily dislodged as to make mastication impracticable."

The Bite.—Having prepared the casts as indicated in

[1] Dr. Gysi claims that the "compensating curve" does not play any compensatory part in the direct forward bite.

Chapter XXVII, a base plate of base plate composition—wax modeling composition or the vulcanized plate (see

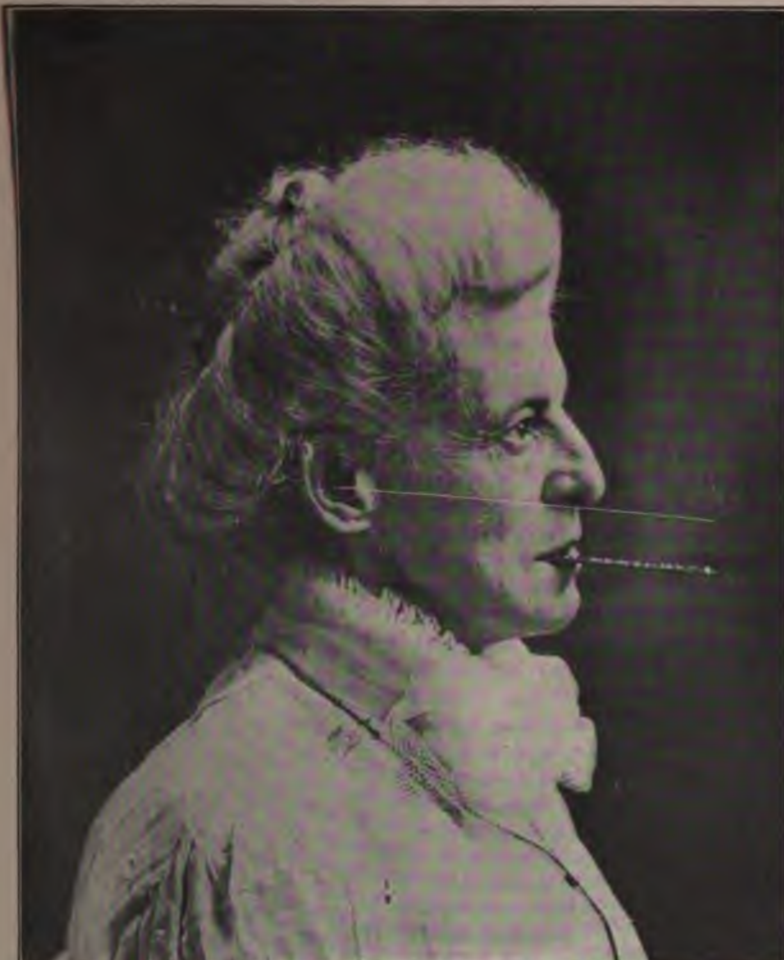


FIG. 170.—OCCLUSAL PLANES OF BITES ESTABLISHED PARALLEL WITH LINE FROM LOWER MARGIN OF AUDITORY MEATUS TO LOWER MARGIN OF ALA OF NOSE. Blade of knife held between bites; handle projecting. (Dr. George W. Clapp.)

double vulcanization method) may be used—is prepared to conform to the outlines prepared for the superior cast. Its adaptation is tested by trial in the mouth,

and, when satisfactory, and prior to adding the roll of softened wax to the gutta percha base plate, a line is drawn upon the patient's face from the lowest point of the external auditory meatus to the lowest point of the ala of the nose (Fig. 170). This line indicates the "occlusal plane," and the occlusal surface of the upper trial plate is to be made on a parallel line with it.

Having prepared the line of the "occlusal plane" upon the patient's face, base plate wax is softened and molded into a roll, adapted to the ridge, and attached to the base plate by means of a heated spatula. The base plate with the wax attached to it is now known as the "trial plate." While the wax is still soft the trial plate is placed in the mouth, and the blade of a suitable knife is pressed against the occlusal surface of the wax upon one side, while the trial plate is supported in position until the projecting portion of the knife is *parallel with the line drawn upon the face* as shown in Fig. 171 (see previous illustration). The flattened surface of the wax formed by the pressure of the blade of the knife will later be altered, but securing this plane of the occlusal surface of the wax will materially aid in securing the desired result in the articulation of the artificial dentures. Having prepared the one side of the trial plate as desired, the other side is made to correspond with it. This should be done outside of the mouth.

When the trial plate has been prepared as indicated it is replaced in the mouth, and the lips allowed to form naturally over the wax. The blade of a knife is carefully inserted between the lips and this line is indicated upon the wax and known as the "rest line."[1] The occlusal portion of the trial plate is now trimmed to within

[1] George W. Clapp.

/16 of an inch of this line, i. e., the occlusal surface
f the trial plate projects 1/16 of an inch below the

Fig. 171. (Dr. Clapp.)

ne of the upper lip upon the wax (see Fig. 172). The
cclusal plane of the wax previously formed should not
e disturbed.

Wax is now softened, formed into a roll, and ad-

justed to the lower base plate after the metho
cated for the superior base plate. The uppe
plate being in position, the lower is placed in the

FIG. 172.—MARKING THE REST LINE. (Dr. Clapp.)

and the patient instructed to close the jaws gentl
the lips lightly touch. The softened wax upon the
trial plate will be pressed into the correct form

occlusal plane by the upper trial plate. The lower trial plate appears short, and is in reality shorter than the

FIG. 173.—EDENTULOUS PATIENT SHOWING DROOPING OF SOFT TISSUES FOLLOWING EXTRACTION OF TEETH.

The labial ends of the alæ and septum droop and the tissues in the labial triangle sink inward. (This picture and FIG. 174 were taken in the same light at the same time, and illustrate very clearly the possibilities in restoration.) (Dr. George W. Clapp.)

teeth to be used, but as the inferior anterior teeth are arranged to articulate with the lingual surfaces of the

superior anterior teeth, adequate room exists for the use of a suitable tooth.

FIG. 174.—PATIENT WITH TRIAL PLATES PROPERLY BUILT UP AND OUT. The tissues in the labial triangle, the alæ and septum, and the corners of the orifice of the mouth have been lifted by making the plate high over the cuspid eminence. Contrast the appearance here and in FIG. 173, preceding illustration. (Dr. Clapp.)

Next attention is given to the labial and buccal contours to restore as far as possible the normal expression

of the face. The wax may be trimmed, or additions may be made in different regions until the countenance appears to have gained the closest approach to the normal, which, in almost all cases, can only be surmised. This procedure is well illustrated in the following illustrations. Fig. 173 shows the patient with the sunken appearance of the tissues about the lips and cheeks. Fig. 174 shows the patient with the trial plates in position and the contour of the face restored.

The High and Low Lip Line.—It is generally observed that in talking the teeth are more or less exposed to view, and in smiling a still greater exposure of the teeth is made. Usually in the act of smiling the upper lip is raised to about the necks of the teeth, and, as the best artistic effects are produced when the artificial teeth are arranged in accordance with the natural plan, the patient is instructed to raise the lip as he would do naturally in smiling, and a line is marked upon the trial plate indicating this position, as illustrated in Fig. 175. This is known as the "high lip line." The distance from this line to the edge of the wax obviously indicates the length of the artificial crown, excepting the portion to be embedded in the vulcanite. Obviously, too, it is safer for the esthetic requirements of the denture if the porcelain of the artificial teeth is exposed to view to the exclusion of the vulcanite, even though they should be a trifle longer than what would appear as the natural length of the tooth.

The patient is next requested to depress the lower lip, that the "low lip line" might be recorded upon the trial plate for similar reasons. As a rule, the lower lip is depressed but a very short distance, and when the jaws are opened the teeth are carried beneath the line of the lower lip. Furthermore, as the artificial teeth

for the lower denture conform to those selected for the upper, the esthetic effect as indicated is effectively carried out even though the "low lip line" is not marked

Fig. 175.—Marking the High Line. (Dr. Clapp.)

upon the inferior trial plate. It is a better plan, however, to register this line upon the wax.

When the length of the anterior teeth has thus been

determined, the space the six anterior teeth are to occupy is next indicated upon the wax. In normal cases it will be found that the distal angle of the superior cuspid is at the corner of the orifice of the mouth when the lips are in a state of rest. This distance is subject to some slight variations. When the orifice is unusually large its corner may be posterior to the distal angle of the cuspid, and when unusually small it may be anterior to it. The judgment of the prosthetist must here be carefully exercised that suitable artistic results may be obtained in the finished denture.

To indicate the distance upon the trial plate, an instrument is inserted between the lips and gently moved to the corner of the orifice and a line marked upon the wax. The same procedure will place the mark upon the other side, in both instances care being taken not to disturb the reposeful position of the lips.

The Median Line.—The artistic effect of the finished piece, no matter how completely realized in all other respects, will be almost entirely destroyed if the anterior teeth are not arranged to correspond to the median line of the face. The frænum of the upper lip usually marks this line, but in some instances it will be found to be on one or the other side of the median line of the face. The face should be closely inspected that the median line may be correctly marked upon the trial plates. The philtrum, or groove in the middle of the upper lip, as a rule, is a reliable guide in indicating this line. Fig. 176 shows the bites with the lines upon it as indicated in the foregoing discussion.

Mounting the Casts with Trial Plates in Position.—As previously indicated, no matter how accurately the articulator may reproduce the movements of the mandible, unless the casts are placed in the same relation to

the condylar joint of the articulator as the natural jaws occupy to the temporo-mandibular articulation, the articulation of the artificial teeth will be a failure. Accuracy in this regard can only be obtained in the use of the "face bow." Until the Gysi articulator appeared

FIG. 176. (After Dr. Clapp.)

which also includes the principle of the "face bow," the *Snow face bow* was the instrument in general use for determining the position of the casts upon the articulator. The Snow face bow can be utilized in conjunction with the Gritman articulator. In fact the original Snow face bow was designed for adjustment upon the Gritman articulator.

Fig. 177 illustrates the face bow, with the old form of the mouth piece; more recently Dr. Snow has introduced a new form. When intended for use, the curved portion of the "mouth piece" is heated and forced into the upper bite plate in such manner that the stem of the mouth piece will be parallel with the occlusal plane of the trial plates, and also project from the median line

FIG. 177.—SNOW FACE-BOW AND PLATE FOR EMBEDDING INTO BITE-PLATE.

of the plates. Care should be taken not to destroy the linear markings upon the wax, previously made, in adjusting the mouth piece.

The next step in the procedure is to locate the position of the condyles upon the face. By placing the forefinger just at the external auditory meatus, and the thumb on the face, and requesting the patient to open and close the mouth, the position of the condyle will be readily determined. Dr. Gysi gives the usual location, as shown in the accompanying illustration, about 10 mm. in front of the *tragus* of the ear and on a line

toward the outer corner of the eye. When the position of the condyle has been determined it should be plainly marked upon the face with a lead pencil.

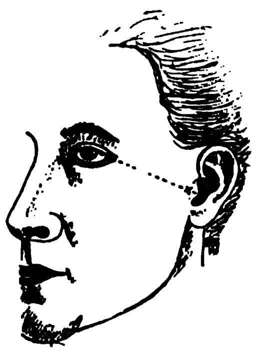


FIG. 178.—POSITION OF THE CONDYLE UPON THE FACE. (Gysi.)

The bite plates with the projecting stem of the mouth piece are now returned to the mouth. The projecting stem should extend forward from the median line. The face bow is now adjusted to position. It is provided with a movable pointer at each end, and a clamping nut to lock the pointer. The central portion of the bow has a swivel clamp perforated for the reception of the stem of the mouth piece, and a set screw which fixes the stem in the desired position. In adjusting the face bow, with one end in each hand, the stem of the mouth piece passes through the opening in the swivel clamp, and each pointer is set firmly against the mark upon the face, until the same number of marks on the pointers appear between the frame of the bow and the face on each side. This is necessary to insure centering the casts. When this has been accomplished the pointers are locked by the clamping nuts, and, while supporting the head of the patient and carefully guarding against displacement of the bow, the swivel clamp is firmly locked upon the protruding stem of the mouth piece.

To facilitate the accurate placement of the face bow Dr. J. N. Prothero devised an attachment for each of its ends. The Prothero device has a sliding rod adaptable to the external opening of each ear, and screws by which the pointers of the face bow may be correctly adjusted.

Fig. 179 illustrates the Prothero attachment, face bow in position.

FIG. 179.—FACE BOW IN POSITION ON PATIENT'S FACE
Prothero attachment on face bow to assist in proper adjustment. Bites in mouth with T piece projecting through swivel clamp on face bow. (Dr. George W. Clapp.)

The face bow and bite plates in position are now removed. The inner surface of each pointer is grooved out to fit the pin extending outward from the joint of

the articulator. The clamping nut about each pointer having been loosened prior to the removal of the face bow, the pointers are pushed in as far as possible and locked. In adjusting the face bow to the articulator, it is spread out, and the grooves within the pointers adjusted to the projecting pins of the articulator joint.

The trial plates should now be adjusted so that the occlusal surface is parallel with the lower bow of the articulator. This is easily arranged by moving the face bow up or down so that the stem of the mouth piece is parallel with the surface of the table.

The upper cast is now placed in its trial plate, and the upper bow of the articulator is adjusted to position and the cast attached in the usual manner with plaster.

When the plaster holding the upper cast in position has set, the articulator is inverted, and the lower cast placed in its trial plate. The bow of the articulator is adjusted to position and the cast attached thereto in the usual manner. In this way alone can the casts be placed upon the articulator to make possible anatomical articulation.

The Determination of the Condyle Paths.—The position of the casts upon the articulator in relation to the joint having been fixed, it is now necessary to determine the inclination of the condyle path of that particular case. In the beginning of the chapter reference was made to the researches of Dr. Walker, which clearly demonstrated the importance of articulating artificial teeth upon an articulator capable of reproducing the incline of the condyle in the forward and lateral movements of the mandible. Dr. Walker also showed why artificial dentures articulated upon the Bonwill articulator, which is only capable of a horizontal or forward movement, inevitably proved a failure when articulation

was attempted with them in the mouth, such articulators being but little better than the plain line articulators. Many of the instruments that were introduced after Dr. Walker's researches appeared were arranged with condyle slots of average inclination, which approximates 33 degrees from a line drawn from the ear to the nose, as shown in illustration. This measurement of the average inclination of the condyle path accords with the researches of Gysi. These were published in the *Cosmos,* January, 1910. For cases which conform to the above measurement, artificial dentures articulated upon instruments with the fixed average condyle inclination give excellent results. But for those cases with a marked deviation from the average inclination of the condyle path, the best results cannot be obtained.

As the method for determining the condyle path is easily mastered, therefore, the indicated procedure in each case is to ascertain the inclination that a closely approximating angle can be fixed upon the articulator, so that the artificial dentures articulated under conditions most closely resembling those of the natural teeth obviously will afford the very best results in the uses for which they are intended. For the Snow articulator and face bow the method is as follows: Two auxiliary pieces are furnished with this articulator, known as "bite gauges" (Fig. 180). The "bite gauges" are forced into the occlusal surface of the lower trial plate, as shown in Fig. 181. When the upper and lower trial plates are brought together the conical projections of the bite gauges produce two openings in the wax of the upper trial plate, as shown in Fig. 182. The trial plates are re-

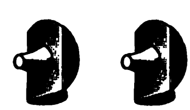


Fig. 180.

placed in the patient's mouth, and the patient is requested to slightly protrude the mandible. When this is done the mandible is forced against the upper jaw until the wax of the upper and lower trial plates is in contact in its anterior region, as shown in the accompanying illustration. In this position a space will also be observable in the posterior region of the trial plates, which is maintained by the conical projections of the

FIG. 181.—LOWER TRIAL PLATE WITH BITE PLATES IN PROPER POSITION. (Dr. George W. Clapp.)

bite gauges. The trial plates are secured in the anterior contact by means of staples, as seen in the illustration, and when thus secured in position they are removed from the mouth and by means of a hot instrument the wax is melted between the upper and lower trial plates, in the anterior and posterior region, to more firmly sustain their relation. Any alteration that might now occur in the relation between the two trial plates would cause an inaccurate reproduction of the condyle slant upon the articulator.

The upper trial plate with the lower attached to it is next placed in position upon the upper cast, and sustained in its exact relation to the cast by flowing melted wax at the edge of the trial plate.

The screws which fasten the condyle slots are turned to loosen the slots, and the spring which holds the two parts of the articulator in motion is disengaged from

Fig. 182.

the lower portion of the articulator. The articulator with the trial plates in position is next inverted and the lower cast accurately placed in the lower trial plate. In order to place the lower cast in position it will be necessary to adjust the condyle slots of the articulator to a certain inclination, determined by the space between the trial plates in the posterior region. When the lower cast is perfectly adapted to the lower trial plate the set screws are turned and the condyle slots fixed. In some

cases the two slots show a difference in their angle of inclination. This most likely is due to the actual difference existing between the slant of the two condyles.

Fig. 183.—Getting the Protruded Bite.
The separator between trial plates at heels, as recorded and maintained by the bite gauges, is clearly shown. (Dr. Clapp.)

When the slots of the articulator have been set by turning the screws, the staples holding the trial plates

together and the bite gauges are to be removed, and the spring returned to its position upon the articulator.

The Compensating and Lateral Curves.—When the condyle path has been determined, the occlusal surface

FIG. 184.—ADJUSTING THE INCLINATIONS OF THE CONDYLE SLOTS BY PLACING THE LOWER MODEL IN THE LOWER BITE. (Dr. Clapp.)

of the trial plates is made to conform to two curves, as designated, which maintain the dentures in position in the forward[1] and lateral movements of the mandible. These curves will form part of the arc of a greater or less circle, in proportion as the condyle slant is near the horizontal—i. e., the nearer the incline of the condyle approaches the horizontal, the less marked these curves will be. The compensating curve, or curve of Spee, runs in the antero-posterior direction, as illustrated in Fig. 185. The lateral curve extends from the

[1] The mechanical side of anatomical articulation.

buccal to buccal side, and is at right angles to the compensating curve.

We cannot do better than quote Dr. George V. Clapp's[1] clear description as to the formation of these curves:

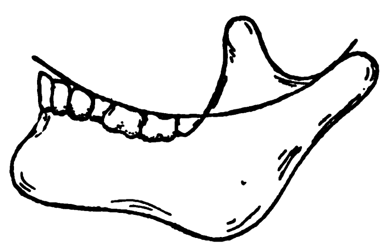


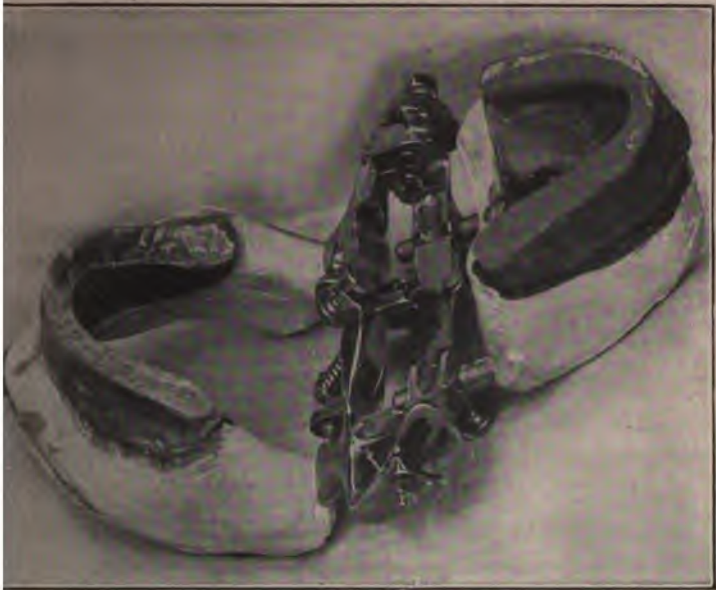
FIG. 185.—THE "CURVE OF SPEE."

"Upon the occlusal surface of the lower trial plate, which was made flat and has not been changed, is dusted a white powder, such as soapstone or talcum, with sufficient evenness so that any scratches upon that surface will show. The trial plates are then closed together and gentle pressure is made from the most anterior portion of the upper model to the most anterior portion of the lower model by means of the thumb and finger. By pressure on the anterior end of either condyle slot the upper model is moved laterally back and forth several times. When the trial plates are separated it will be seen that the occlusal margin of the upper trial plate on one side has rubbed the powder noticeably in several spots. If both occlusal surfaces are smooth and level this rubbing will probably occur first in the bicuspid region. This is shown by the dark spot on the occlusal surface of the lower trial plate at the location of the right bicuspids in Fig. 186.

"The wax of the lower trial plate is now scraped where the powder was rubbed. For this some workers prefer an old blade from a safety razor, and some prefer a wooden-handled ink eraser, such as is common in business offices. When the wax in the rubbed area has

[1] Dr. Gysi claims that the curve of Spee does not play any part in the forward bite.

n hollowed somewhat, fresh powder should be dusted and the rubbing and scraping process repeated. hen the necessary technique has been acquired the aping or carving can be done rapidly, since the in- ations of the first rubbing will prove a reasonably urate guide for extensive carving. But it cannot be ed too strongly upon dentists who care to anatomi-



186.—MOVING THE UPPER MODEL LATERALLY RUBS THE POWDERED SURFACE OF THE LOWER TRIAL PLATE. (Dr. Clapp.)

y articulate dentures that in the first two or three of trial plates there should be given to this carving ugh time and attention to demonstrate the principles methods involved. The time spent in doing this bring ample rewards in the future. Trial plate ing will never again offer difficulties.

'This form of carving should be continued on one only until the upper trial plate rubs the powdered

surface of the lower to the outer margin on that side. The other side may then be carved in like manner. This is as far as this form of carving should be carried, since it is not desired to lower the labial margin of the lower trial plate. If the trial plates be now closed together and examined from the lingual, it will be seen that, while the outer margin of the lower trial plate remains undisturbed, the occlusal surface has been considerably inclined toward the lingual. This inclination will be least in the molar region and greatest at the median line.

"If the upper model be moved to the right the trial plates will now remain in contact on the left side, but separate noticeably in the molar region on the right. The amount of separation will depend almost wholly on the inclination of the condyle slots. If this inclination be very slight, say only 10 degrees, separation between the heels will be slight. If, however, the inclination of the condyle slots be 33 degrees, which Gysi thinks is the average, the separation will be noticeable. If the inclination of the condyle slots should be 60 or 70 degrees, as is found in some cases, the separation will be very marked.

"The next task is to so continue the curves in the occlusal surfaces of both trial plates that this separation in the lateral movement may be overcome. This may be done by building up the heel of the lower trial plate into the compensating curve and then carving the heel of the upper trial plate to fit the lower as thus built.[1]

"The heel of the lower trial plate is built up as follows: Cut across one end of a sheet of base plate wax as it comes in the box, making a strip about three-fourths of an inch wide. Soften this on one side and fold, and

[1] Credit for the following method should be given to Dr. E. S. Ulsaver. It is one of the best mechanical steps in this method.

repeat the softening and folding until a roll has been made which is soft all the way through. With gentle heat soften one heel of the lower trial plate, place the little roll thus made on the heel, and attach it firmly by means of a hot spatula thrust through the roll and into the wax. When this union is sufficiently firm for working purposes, moisten with water the occlusal sur-

FIG. 187.—THE COMPENSATING AND LATERAL CURVES SO WORKED OUT THAT THE TRIAL PLATES DO NOT SEPARATE. (Dr. Clapp.)

face of the upper trial plate directly over the roll. Before bringing the trial plates together, move the upper model about one-eighth of an inch toward the side on which the roll is attached. With the upper thus moved laterally, press the models together until the trial plates come in contact on the side opposite to the roll (Fig. 187). Separate the trial plates and trim away the excess of wax to the lingual and buccal margins. It will be observed that the upper ridge did not flatten the roll hori-

zontally, but that this surface shows an inclination upward and backward from the occlusal surface of the lower trial plate. This is the beginning of the compensating curve. This surface also slopes lingually—that is, the elevation is less at the lingual margin than at the buccal margin. This is the beginning of the lateral curve in this section.

"It has been suggested that the upper model be moved laterally only about one-eighth of an inch, because it is found that if the model be pulled farther the compensating and lateral curves are exaggerated. So far as we are able to determine at present, practically all the benefits that would be possible from even the most exaggerated curve are secured by the curve that results from moving the upper model one-eighth of an inch. Dentists who wish to carry their education out in this matter will find it profitable to make a set of trial plates and in carving to move the upper model as far laterally as the articulator permits. This will give an understanding of the compensating and lateral curves, which will be impossible of attainment by any other means. When the upper model is allowed to return to a position of central occlusion, the trial plates will be kept apart by the built-up heel of the lower (Fig. 188). At the point of contact with the lower, the upper must be carved to permit the trial plates to come together all around. Begin scraping at the buccal-occlusal margin in the cuspid region, scraping harder as the heel is approached. The scraped surface of the upper should have just the same upward and backward inclination as the built-up heel of the lower. It should have just the same lateral curve, so that in the position of central occlusion the built-up surface of the lower and the scraped surface of the upper show nearly exact contact.

"The heel of the upper should be scraped in a curve somewhat longer than that shown by the built-up wax on the lower trial plate. That probably extended forward only to the bicuspids. It terminated abruptly, leaving a sort of 'jumping-off place.' The curve of the upper necessary to fit the built-up lower may be carried

Fig. 188.—Bites, in Central Occlusion, kept Apart by Built-up Heel of Lower. (Dr. Clapp.)

forward to the location of the cuspid. When the trial plates are in contact all around this will leave a triangular open space anterior to the flattened roll. This should be built in with soft wax and the upper trial plate moistened and closed down on it. This will shape it to conform to the curve in the upper.

"If, by pressure on the same condyle slot as before, the upper model be now moved laterally, a slight separation will probably occur between the heels of the upper and lower trial plates. This is due to the fact that the upward curve of the lower trial plate was shaped by

the occlusal surface of the untrimmed upper. The upper now having been trimmed, its occlusal surface occupies a somewhat different position, hence the separation. Another roll of wax is attached to the occlusal surface of the lower trial plate in the same place and in the same way as the first. The occlusal surface of the upper is moistened and the upper model is again moved slightly toward that side and pressed down until the trial plates come in contact on the opposite side. This will be found to again increase the height of the heel of the lower on that side, and to increase also the compensating and lateral curves. The upper trial plate is again carved on that side until proper relations are established. It may now be found that, when the upper model is moved laterally through the one-eighth inch of distance, the heels of the two trial plates will not separate. Should a separation of any size occur, it may be remedied by a third building in like fashion. By this means the compensating and lateral curves may be so accurately worked out that no separation is perceptible between the trial plates through the range of movement mentioned. The trimming of the wax may usually be accomplished in much less time than is here required to describe it, and with a little practice the whole operation becomes very rapid."

Reference has been made previously to the instrument devised by Dr. Gysi which makes possible all the masticatory movements with artificial dentures. In providing for the reproduction of all the movements of the natural teeth Dr. Gysi was influenced by his determination that the center around which the circular movement of the mandible takes place is in a different location from that assumed by Spee, who indicated its position as being "between the orbital cavities or above them

in the median line of the face."[1] Dr. Gysi discovered that the tooth curve does not play any compensating part in the direct-forward bite, and constructed his articulator to conform only to the rotation point, "which lies in the condyle axis, which alone plays a rôle in the lateral movements, and which is the true rotation point in the small opening movement necessary before lateral or masticatory movements are possible."

Dr. Gysi claims that the tooth, or so-called "compensating curve," may be determined in the following ways:

"1. By the amount of its depression below the occlusal plane—expressed in millimeters.

"2. By the length of its radius.

"3. By the angle at which the curve meets the occlusal plane."

It is by the last method, especially by that angle at which the extreme posterior portion of the tooth curves, or the slant of the last lower molar in a sagittal plane meets the occlusal plane, that Dr. Gysi determines the curve.

Dr. Gysi also emphasizes the length of the incisal overbite as an important factor in the movements of the mandible, and with a specially constructed instrument the relation between the overbite and the condyle path and the balancing points can be determined.

For all the details of Prof. Gysi's elaborately worked out method of reproducing the movements of natural teeth, the reader is referred to his publication on "The Problem of Articulation."

The Selection and Adaptation of Artificial Teeth.—When the trial plates have been mounted according to the principles previously discussed, the type of teeth to be selected in regard to form, color, and size should

[1] Gysi, *Cosmos*, February, 1910.

conform to the requirements of the case at hand. In the preparation of the upper trial plate the size of the teeth to be adapted to the case has been, in part at least, determined; but this, as well as the form and color, should conform to the general temperamental attributes of the patient. The important desideratum is the restoration of the natural appearance of the individual, and, while this may not be attainable, or even desirable, in all instances, it is the end sought in selecting the artificial teeth, unless the natural appearance of the patient has been associated with a marked defect of one or more of the natural teeth, in which case it may not be desirable to restore the former appearance.

In selecting teeth not only does the form, color, and size play an important part in the final choice, but the arrangement of the lingual surface of the artificial tooth in relation to the necessities of the case also plays an important part in the final selection. The importance of this is so frequently disregarded, as may be observed from the many cases of improper adaptation of the teeth to the ridge, that a few words descriptive of the arrangement of the lingual surfaces of different teeth may not be out of place. The lingual surface of an incisor presents three parts, viz., "the bite," "the shut," "the ridge lap." The bite is that portion of the lingual surface extending from the incisal edge to the ledge from which the pins project. The shut is the ledge from which the pins project. The ridge lap is that portion extending from the shut to the cervical end, and is the part to be adapted to the ridge. The accompanying illustration (Fig. 189) shows the three divisions.

This division of the tooth has much to do with the selection made for any particular case, and, in order to meet the requirements of different cases, manufacturers

design the lingual surface to meet the various indications.

The ridge lap of the artificial tooth is the only portion of the tooth to be upon the ridge, the neck of the tooth reaching to the high lip line marked upon the trial plate, the bite and shut being properly related to the ridge below it, with the cutting edge of the tooth extending to the end of the wax of the trial plate.

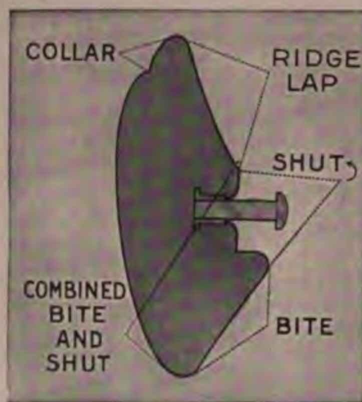


Fig. 189.

When the distance from the ridge to the incisal portion of the trial plate is short, a tooth must be selected in which the combined measurement of *bite* and *shut* will conform to the short distance indicated, and


Fig. 190.


Fig. 191.

where the long ridge lap will properly conform to the deep ridge (Fig. 190). If the length of the bite, inde-

pendent of the shut, alone is considered, the best results will not be obtained. This error is frequently made.

In those cases marked by considerable resorption of the ridge, the distance to the incisal edge is increased, and a type of tooth must be selected which has a *short ridge lap* for the short ridge, and in which the *bite* and *shut* together conform to the greater distance from ridge to the incisal end of the trial plate (Fig. 191).

It is essential in all cases to determine the distance from the surface of the ridge to the incisal edge of the trial plate, which can be done quite readily, and then select a tooth with a combined bite and shut to conform to this distance. In those cases where the ridge is thick linguo-labially, it will be better to select teeth having a combined bite and shut measurement slightly in excess of the distance from the surface of the ridge to the incisal edge of the trial plate, and slightly in excess of that used in cases where the ridge is thin linguo-labially.

Articulating the Teeth.—The arrangement of the teeth and their adaptation to the requirements of the case is a simple procedure when the proper preparation, as previously discussed, has been made for the determination of the curves of the teeth, the contour of the lips and cheek, and when the selection of the teeth has been based upon the measurements of the case, as previously noted. Under these favorable conditions the artificial teeth may easily be arranged to meet the various functions for which they are intended. Concerning the artistic sense displayed in their arrangement to conform to temperamental or other peculiarities, or the imitation of slight forms of irregularities to more closely simulate a natural appearance, but little need be said here. The degree of success achieved in this regard

is proportionate to the artistic sense possessed by the dentist, and to the earnestness with which each case is treated.

When the teeth have been selected the wax upon the upper trial plate is cut away upon one side, to accommodate the placing of the teeth, and the central incisor is set in position. If the teeth have been selected according to the plan previously indicated, the incisal edge of the tooth will be in contact with the incisal margin of the lower wax, and each tooth may be set in position until all are in place upon that side. The introduction of anatomical bicuspids and molars has made anatomical articulation possible without the grinding which, prior to the introduction of these molds of teeth, was not only necessary, but in which so few could gain proficiency without the expenditure of more time than is usually at the command of the practitioner.

When one side of the upper set has been arranged and waxed in position, the wax upon the other side is trimmed down, and the teeth of the other side set in position. The upper set is now in position with the incisal and occlusal surfaces in contact with the wax of the lower trial plate. The upper model may now be moved a short distance laterally, and on the side toward which the movement is made the lingual cusps should be in contact with the lower wax. Upon the opposite side the buccal and lingual cusps should also be in contact with the lower wax, unless the lateral movement has been too wide, in which case the buccal cusps alone will be in contact. When the teeth upon both sides are found to be in their correct relation with the lower wax, the half of the lower wax is cut away for the accommodation of the lower teeth to be articulated with the upper set. Dr. Clapp recommends setting the lower first molar in

position first. With the improved molds at the command of the dentist, the tooth is readily placed in position. The second molar is set next, followed by the lower second and first bicuspid. The teeth upon the other side may now be set in position in the order previously indicated, and when waxed in place the lower anterior teeth are arranged to meet the requirements of the case.

Dr. Clapp further recommends that the teeth should be set in their respective positions as indicated, without any attempt at this time being made to grind them to perfect the articulation. When the articulation has been tested upon the articulator and found to be satisfactory, he advises the removal of the upper model with the denture in position, and the case completed by vulcanizing in the usual manner. When this has been done the vulcanized plate is returned to its position of occlusion with the lower case, which is still in place upon the articulator, and while in this position it is secured to the articulator by means of plaster. The lower model is now removed and the steps of the process advanced by vulcanizing, similar to the procedure for the upper case. When the lower case has been vulcanized it is placed in occlusion with the upper set, which previously has been secured in its proper position upon the articulator, and attached with plaster to the lower bow of the articulator. The articulation may now be completed by removing the points of the cusps which may have been slightly moved out of position during the process of vulcanization, and which, therefore, may interfere with perfect articulation between the two sets.

Dr. Clapp claims for this plan not only greater accuracy in the final result, but also a saving of considerable time. And by the use of the carborundum paste

the glaze is removed from the occlusal and incisal surfaces, advantageous for the retention and crushing of food.

When the grinding down process is completed, and the upper jaw of the articulator is moved laterally, the teeth upon the side toward which the movement has been made should show the buccal surfaces of the superior and inferior teeth in the same vertical plane with contact from the incisor backward. Upon the other side there should also be contact from the first bicuspid backward.

When the upper model is carried backward to bring the superior and inferior incisors in end to end relation, the superior cuspid is in contact with the inferior first bicuspid; the superior first bicuspid with the inferior second bicuspid; the superior second bicuspid with the mesial cusp of the inferior first molar, etc. This insures the support of the superior denture in the initial effort of incising the food, and, as the inferior incisors pass upward upon the lingual surfaces of the superior incisors, the posterior teeth will slide into place upon the inclined planes of the cusps.

Vulcanizable rubber as a base for artificial dentures is prepared by purifying the caoutchouc originally obtained as the milky juice of various species of trees and plants (the finest quality is obtained from Para, Brazil, called Para Caoutchouc), and after its purification admixing it with sulphur in varying proportions, dependent upon the use for which the compound is intended. The soft pliable variety used in the construction of artificial vela (see chapter on Palatal Mechanism) is admixed with sulphur to 20 per cent. of the weight of gum, while the vulcanizable rubber for dentures is admixed with sulphur equal to about one-half of the weight of caoutchouc. Beside the admixture of sulphur coloring matter is also added in the following proportions:

Dark Brown—Caoutchouc, 48 parts; sulphur, 24 parts.

Red—Caoutchouc. 48 parts; sulphur, 24 parts; vermilion, 36 parts.

Dark Pink—Caoutchouc, 48 parts; sulphur, 24 parts; white oxid of zinc, 30 parts; vermilion, 10 parts.

Grayish White—Caoutchouc, 48 parts; sulphur, 24 parts; white zinc oxid, 96 parts.

Black—Caoutchouc, 48 parts; sulphur, 24 parts; ivory-black or drop-black, 24 parts.

Jet Black—Caoutchouc, 48 parts; sulphur, 24 parts; ivory-black or drop-black, 48 parts.

These formulas are the outcome of the experimental work done by Prof. Wildman a number of years after the patent rights were granted to Charles Goodyear for a process for vulcanizing rubber. This patent was granted in 1844, and, according to the stated proportion of admixed sulphur, covered the process for the production of soft, flexible vulcanite.

Nelson Goodyear, in 1851, patented the process for producing hard rubber. In this process one-half pound of sulphur was admixed with one pound of caoutchouc and one-half pound of some earthy substance.

Other patent rights were granted in 1855 to Charles Goodyear, Jr., for improvements in plates for artificial teeth, and in 1857 to H. H. Day for vulcanizing very thick pieces of rubber by admixing with the caoutchouc a substance capable of absorbing the sulphur gases as rapidly as eliminated in the process of vulcanization.

The Process of Vulcanization.—Most writers in discussing the chemistry of vulcanization state that the process is accompanied by the evolution of hydrogen sulphid, indirectly claiming it to be a substitution and not an addition process. In a series of investigations conducted by Carl Otto Weber, Ph.D., and published in 1903, and to which attention is directed by Dr. George H. Wilson, the following appears, and from which we may deduce that dental vulcanite is principally *polyprenedisulphid,* $C_{10}H_{16}S_2$, containing 32 per cent. of combined sulphur:

"These figures (referring to experiments) amply suffice to demonstrate indisputably the fact, even quite recently again denied, that the vulcanization of India rubber with sulphur involves the chemical combination of these two substances, at any rate as far as the vulcanization of Para rubber is concerned.

"The extremely interesting results here tabulated remove all doubt that the vulcanization of India rubber is a chemical process resulting in the formation of a polyprene sulphid. The rate at which the sulphur enters into combination with the India rubber hydrocarbon (polyprene) is characteristic for each brand of India rubber. Some of the above series were repeatedly investigated, always with the same result.

"There arises now, of course, at once the question as to the nature of the process by which sulphur enters into combination with the polyprene, whether the polyprene sulphid or sulphids formed are addition or substitution products. Certainly what we already know respecting the chemical nature of India rubber leads us to infer that the vulcanization process consists essentially in the formation of an addition product of sulphur and polyprene. This assumption, however, requires support, in view of the fact that quite a number of writers, from Payen to most of the recent authors, declare that vulcanization is accompanied by the evolution of hydrogen sulphid, thereby implying that the process is a substitution, and not an addition process. Indeed, most of the recent authors on this subject state this in so many words. We shall, therefore, have to subject this point to a careful examination.

"Assuming the compound of polyprene and sulphur, which indisputably forms in the vulcanization process, to be a substitution product, it follows with absolute necessity that for each 32 parts of sulphur combining with the polyprene we must obtain 34 parts of hydrogen sulphid. Now, in the process of vulcanization as practically carried out we obtain on an average a product containing, say, 2.5 per cent. of combined sulphur. Consequently the vulcanization of one ton of India rubber,

on the above assumption, would be bound to yield very nearly 60 pounds of hydrogen sulphid, or approximately 18,000 liters. Considering that in a number of factories the amount of India rubber vulcanized daily largely exceeds one ton in weight, we should expect to find the vulcanizing rooms of these factories reeking with gas. As a matter of fact, however, there is scarcely ever a trace of this gas to be discovered in the rubber works' atmosphere, and the very rare cases in which its presence becomes noticeable may always be considered as an indication of something having gone wrong.

"In the vulcanization of 'hard rubber' goods (ebonite vulcanite) faint but distinct traces of hydrogen sulphid are generally, perhaps always, observable, but they could not be ascribed to the vulcanization process proper—the combination of polyprene with sulphur—which process, if it consisted in the substitution of hydrogen for sulphur, should cause a perfectly torrential evolution of hydrogen sulphid, seeing that 'hard rubber' contains at least 20 per cent. of combined sulphur.

"It is, therefore, certain that, if hydrogen sulphid forms at all in the vulcanizing process, its amount is utterly inadequate to support the assumption that the process of vulcanization is a substitution process."

Later Dr. Weber states: "From these facts we are justified in drawing the following conclusions:

"1. The India rubber hydrocarbon, polyprene, $C_{10}H_{16}$, combines with sulphur without evolution of hydrogen sulphid. The vulcanization process of India rubber is, therefore, an addition process.

"2. The insoluble constituent of India rubber, which forms only an insignificant proportion of the technical product, not exceeding five per cent. of the total, combines with sulphur under vulcanizing conditions at a

very slow rate with evolution of hydrogen sulphid and with the formation of a substitution product.

"The above conclusively settles the question regarding the general chemical aspect of the vulcanization process, but it confronts us with the further question respecting the quantity of sulphur combining with India rubber in this process, as well as the more intimate structure of the compound thus formed."

In conclusion Dr. Weber states:

"The process of vulcanization consists in the formation of a continuous series of addition products of polyprene and sulphur, with probably a polyprene sulphid $C_{100}H_{160}S_1$, as the lower, and $C_{100}H_{160}S_{20}$ as the upper limit of the series. Physically this series is characterized by the decrease of distensibility, and the increase of rigidity, from the lower to the upper limit. Which term of the above series, that is, which degree of vulcanization is produced, is in every case only a function of temperature time, and the proportion of sulphur present.

"As a chemical reaction the vulcanization process is not influenced by the physical state of the India rubber colloid; but the physical state of India rubber colloid, while under vulcanization, largely determines the physical constants of the vulcanization product. As previously stated, Dr. Weber's experiments, to which the reader is referred, appear to scientifically establish that dental vulcanite is polyprene disulphid with a formula of $C_{10}H_{16}S_2$, and is not, as has been previous to these experiments so generally claimed, practically a hardened carbon, with the H of the original carbohydrate molecule removed by the admixed sulphur in the evolution of hydrogen sulphid."

Technique of Constructing Vulcanite Dentures.—The construction of vulcanite dentures may be classified un-

der two heads, the *double vulcanization method* and the *single vulcanization method.*[1] The former method is generally indicated where extensive restoration of gum tissue is to be made, the latter method to cases where little or no gum restoration is to be made.

DOUBLE VULCANIZATION METHOD.—FULL UPPER.—Having obtained a plaster impression as outlined in Chapter XXVI, the cast is prepared, preferably of Spence compound, with a thin facing of pure plaster, for reasons previously stated (see chapter on Preparation of Cast). When the cast has been separated and prepared according to the requirements of the case, as recommended in the chapter referred to above, a sheet of thin base plate wax is softened and adapted over the surface of the cast to form the *base plate.* When this has been desirably adapted to the cast, and allowed to extend over its sides one-sixteenth of an inch beyond the outline prepared for the plate, it is attached to the cast by means of a hot spatula, and subsequently flasked in a manner that will admit of the separation of the two parts of the flask taking place at the periphery of the wax.

When the flask has been heated and opened, the softened wax is removed, the cast and mold are prepared to receive the excess of rubber, and when the surface of the cast has been coated, preferably with tin foil, to give a desirable finish to the completed piece, the cast and mold portion of the flask are subjected to heat until the plaster is heated, but not beyond that it may still admit of digital contact. A suitable piece of brown or black rubber, to slightly exceed the requirements of the case, is placed in the mold, the two portions of the flask

[1] Dr. George H. Wilson in "American Textbook of Prosthetic Dentistry."

placed in apposition, and forced together in the flask press until closed.

The flask is then clamped or bolted, placed in the vulcanizer, and heat is applied until the thermometer indicates 320° F., at which degree it is sustained for about fifty minutes. When this has been done the flask is allowed to cool, the base plate removed, trimmed to the desired outline, and the outer surfaces scraped for the contouring addition to be made subsequently.

Intentional omission is made of any discussion relating to the different forms of flasks and vulcanizers, also of the various instruments employed in obtaining the desirable outline and finish of the completed case. Most practitioners are quite thoroughly acquainted with these, and soon manifest a leaning toward the use of special forms of instruments, as has been elsewhere stated, showing greater aptitude in their utilization than in the utilization of other forms.

The base plate having been completed as previously discussed, it should be tried in the mouth and its adaptation carefully noted. The reader is referred to the chapter on Swaged Metallic Plates for the discussion of the retention and outline form of the plate preliminary to the taking of the "bite." What is there stated in regard to the requirements of the plate is applicable here. The labial and buccal movable tissue must be avoided; the plate should not extend too far posteriorly; pressure applied at one part of the ridge should not cause dislodgment of the plate, etc. If any fault is observed it should be corrected before proceeding to the next step of the operation, or, if correction of the fault is not attainable, a new impression should be taken, and the base plate again formed as indicated. When a satisfactory base plate has been formed, wax is softened

and adapted to the ridge until a desirable contour is obtained. The subsequent procedure is similar to that discussed in the chapter on Taking the Bite, to which the reader is referred.

When the teeth have been arranged and articulated, the plate should be placed in the mouth, that the articulation, contour, and arrangement of the teeth may be finally studied.

Preparing the Gum Festoons.—When the case satisfactorily meets the requirements, the gum festoons are next outlined. Dr. George H. Wilson[1] describes his method of utilizing waxed dental floss to effectively outline the gum margin in the following manner:

"The string used for this purpose is waxed dental floss, twisted very hard, doubled and twisted again. In doubling, the loop will show the direction in which it should be twisted the second time. Wax the string well with softened wax and apply it by grasping the left heel of the plate between the fingers and thumb of the left hand, with the occlusal surfaces of the teeth upward; place one end of the string at the distal surface of the second molar, pressing it gently into the wax; outline the margin of the gum, using the wax spatula to carry the string well into the interproximal spaces. The peripheral string should be well-waxed wrapping twine, placed at the outer edge of the wax and secured in place by melted wax made smooth with a hot spatula (Fig. 192).

The Application of Tin Foil.—Tin foil No. 60 is next adapted to the buccal and labial portion of the wax by first adjusting the foil to position over the surface of the wax and teeth, forcing it into a smooth and close adaptation by means of pressure applied with the fin-

[1] "American Textbook of Prosthetic Dentistry."

gers. When the tin foil has been satisfactorily adapted, the excess is cut away by means of a sharp instrument to within about 1/16 of an inch of the waxed silk forming the gum festoon. When the excess has been cut away and the foil adapted to meet the requirements, the lingual surface is also covered with No. 60 tin foil. In order to secure a desirable adaptation it will be necessary in most cases to cut the foil, after which a close and smooth adaptation can easily be obtained. To secure the form of the rugæ it has been recommended [1] to remove the foil from the cast, and by placing it upon a cast having well-defined rugæ, and forcing it into close adaptation to the surface of the second cast, the form of the rugæ are easily reproduced in the tin foil. When this has been accomplished the tin foil is removed from the cast and melted wax poured into the impression of the rugæ. A thin layer of wax may also be applied to the remaining portion of the tin foil after which it is returned to the cast and effectively adjusted into position, clearly outlining the lingual surfaces of the teeth.


FIG. 192.—GUM FESTOONS FORMED WITH STRINGS. (After Dr. Wilson.)

Dr. Wilson claims [2] that better results are obtainable if Spence's compound is poured into the maxillary surface of the case and the case flasked in the Wilson flask. The cast thus made of the Spence compound, upon which the vulcanization will now take place, is allowed to harden for one and a half hours, after which it may be set in the flask with ordinary plaster. When this has

[1] Dr. A. DeWitt Gritman.
[2] "American Textbook of Prosthetic Dentistry."

hardened it is coated with a separating solution, and the flasking and subsequent vulcanization completed in the usual way.

SINGLE VULCANIZATION METHOD.—In this method a mix of the Spence compound is first poured into the plaster impression, and the body of the cast formed with an ordinary plaster of Paris mix, as discussed in the chapter on The Preparation of The Cast. When the cast has been separated a base plate of modeling composition, paraffin and wax, or any other suitable material, is prepared, the bite secured, and the case mounted upon the articulator. The teeth and contour are arranged to meet the requirements of the case, after which the case is finished in the usual manner. It is in the determination of the articulation, arrangement of the teeth, and contour that the advantages of the vulcanized base plate become emphatically manifest. In many cases where the wax, or similar base plate, is utilized, it yields under the pressure of the muscles acting upon the mandible, making it extremely difficult to determine the important relations of articulation, arrangement of the teeth, and the contour.

Partial Cases.—In those cases of partial plate construction where no special provision is made to aid the retention of the plate, as is usually done in the utilization of the clasp or telescoping crown, the procedure is similar to that previously discussed, excepting as the flasking of the case may demand different treatment. Where the clasp or telescoping crown is utilized, it must be provided with a projecting piece of metal which becomes imbedded in the vulcanite, after it has been properly adapted to the wax bite plate.

A somewhat similar procedure is necessary when the bite precludes the use of the ordinary tooth, and neces-

sitates the use of a facing or plate tooth. Fig 193 illustrates the tooth and clasp.

In constructing a partial lower plate for replacing the posterior teeth, the lingual bar method of construction has almost entirely superseded the former methods of construction. The reader is referred to the chapter on Bridgework for detailed information.

FIG. 193.

Vulcanite in Combination with a Metallic Base.—Vulcanite in combination with either silver, platinum, aluminum, gold, etc., yields an excellent denture. The combination of vulcanite with gold is generally preferred, although, since the method of casting aluminum has been perfected, this metal is frequently utilized in combination with vulcanite, where formerly gold was used.

Platinum is not well adapted as a base for dentures, owing to its lack of rigidity. The exception to this is to be found in continuous-gum construction, where the presence of the porcelain overcomes the deficient rigidity of the platinum; also in cases where the platinum is alloyed with some other metal which imparts to the alloy the necessary rigidity.

The utilization of silver as a base in combination with vulcanite is not well founaed, when its use is prompted by economy in comparison to the greater cost of gold. The difference in the cost between the two metals is equalized in the greater expenditure of time necessary for the construction of the silver and vulcanite denture. Furthermore, the subsequent discoloration of the silver in the mouth is a well sustained objection against its use. To overcome the objection of the subsequent discoloration of silver when utilized as a base

for dentures, also to prevent the action of the sulphur admixed with the rubber, and for which this metal has a great affinity, silver is alloyed with platinum. But the alloy of silver and platinum has not been entirely successful in eliminating the objections previously indicated, especially in regard to the affinity for the sulphur admixed with the rubber, and which, unless prevented from becoming active by interposing tin foil between the rubber and the metal base, interferes with the formation of polyprene disulphid, or vulcanite. Gold is the metal generally preferred in combination with vulcanite. The procedure involves, first, the construction of the plate as indicated in the chapter on Swaged Metallic Plates. When this has been satisfactorily accomplished, a piece of 17 or 18 gauge half round gold wire should be soldered to the labial and buccal edge of the plate, and when the position of the teeth has been determined, the lingual face of the plate is also provided with the wire, the location of which being marked upon the plate after the teeth have been anatomically articulated. While the vulcanite can be combined with the gold, without the wire, the finish of the piece is never as good. The position for the loops to be soldered to the plate for the attachment of the rubber should be marked upon the plate after the teeth have been articulated, in order that their position upon the plate should not interfere with the proper position of the teeth.

Vulcanite Plates with Metallic Linings.—Numerous attempts have been made to form a permanent metallic coating for the surface of the plate in contact with the mucous membrane of the mouth with but indifferent success. One method is to electro-deposit gold upon the surface of the plaster cast, after it has been made impervious to warm water and coated with plumbago and

painted with a solution of chlorid of gold. A somewhat similar method is to use sheets of No. 8 or 10 gold foil with a non-conductor between them, to seal the edges to prevent the gold solution from passing through the foil. Gold or copper can be deposited upon the exposed surface, the metallic body adhering to the plate after vulcanization. The "vulcan gold lining" method consists of adapting the lining, which is a sheet of pure gold with a coating of silver upon it, to the cast. The action of the sulphur upon the silver causes adhesion of the lining.

In utilizing this method the case is first flasked and subsequently opened. The surface of the cast should

Fig. 194.

Fig. 195.

be thoroughly smooth. It is also to be painted with a thin solution of equal parts of shellac and sandarac in alcohol, and, when dry, a coating of gum tragacanth or damar varnish is applied, and before this has dried the gold lining, which has been cut into convenient forms, is pressed into place upon the cast with the gold side down. When the cast has been satisfactorily covered the flask is closed and the case vulcanized.

Dr. Speyer advocates lining dentures with a thin metallic plate of about No. 120 foil which has been pre-

pared in the form illustrated in Figs. 194 and 195. It is claimed that in the use of this lining a strong plate adhesion is secured without causing any irritation of the mucous surface.

Weighted Rubber.—Where additional weight is desired in constructing a full lower denture, without the privilege of utilizing either gold or platinum, a rubber containing tin filings is used, and the extra weight thus secured in many cases is decidedly advantageous for the retention of the plate.

Repairing Vulcanite Dentures.—When the denture is in two parts, these are perfectly adjusted and sustained in relation by means of wax flowed over the lingual surface. When the wax has hardened, the maxillary portion of the plate is filled with a mix of plaster and set aside to harden. When this has hardened the plate is removed from the cast, the fractured edges filed down about 1/16 of an inch on each side, and dovetailed spaces cut into each portion of the plate. The space is then filled with wax, flasked, and vulcanized, as previously indicated.

It is claimed[1] that more satisfactory results are obtained if, after the cast has been made, the fractured parts of the denture are removed, the edges of the fracture beveled down to a feather edge, the bevel measuring from 1/8 to 1/2 an inch. A slight bevel is also formed upon the maxillary portions of the fracture. The trimmed portions of the plate are restored with wax, and after preparing wax shafts which later form openings into which the rubber is packed, the case is vulcanized in the usual manner. Another method, whereby practically a new denture is formed, is to accurately appose the fractured portions of the plate, and when held in position by wax a plaster mix is poured into the

[1] Dr. Wilson in "American Textbook of Prosthetic Dentistry."

maxillary portion to form a cast. A guide is next prepared for the teeth, after which the teeth are removed from the plate and set in their respective positions in the guide. The case is then waxed, flasked, and vulcanized in the usual way.

Interdental Splints.—Interdental splints made of vulcanized rubber were first described about the same time by Dr. F. B. Gunning of New York and Dr. J. B. Bean of Atlanta, Georgia. Each claimed to be the originator of the device, but it appears that their efforts, although conducted about the same time, were carried on without knowledge of what either investigator was doing; therefore the credit for the origination of the appliance is shared by both. The two splints are similar, but differ in the form of the submental compress and bandage.

The Gunning splint is made to include the superior and inferior teeth, with a perforation for the passage of food. The splint is retained in position by means of a bandage applied to the inferior jaw and the head. Dr. Gunning also constructed other forms of splints, some of which were made to cover only the inferior teeth.

In constructing a splint a suitable tray is selected and well oiled, to facilitate its separation from the plaster. A plaster of paris mix is made in the usual way, and when it has set, after being adjusted to the parts, the tray is removed, which can be done quite easily if it has been oiled, the plaster removed in sections and correctly assembled upon the tray. In this manner a satisfactory impression can be secured with a minimum degree of infliction.

An impression is next secured of the superior teeth, and casts prepared for both the upper and lower jaw. When this has been done the fractured portion is cut out upon the cast for the lower jaw, and adjusted to a

correct articulation with the superior teeth. When the articulation has been satisfactorily adjusted the adjusted section of the cast for the inferior teeth is secured in its corrected position by the addition of a thin mix of plaster. The case should now be mounted in the articulator, which is arranged to open the casts about a quarter of an inch. Dovetailed spaces between the teeth should be filled in with plaster, that the finished piece

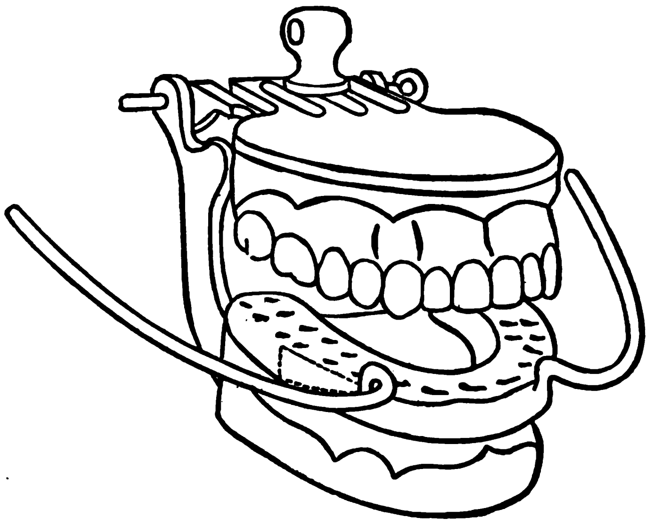


FIG. 196.—MODEL OF MANDIBULAR SPLINT ON THE ARTICULATOR. ("American Textbook of Prosthetic Dentistry.")

will admit of an easy adjustment. For a similar reason No. 60 tin foil is adapted to the cast. Sheet wax is next fitted to the casts to form the splints and sufficient wax placed between the upper and lower wax form to unite them.

The wax splint may now be removed from its position upon the casts and invested in the usual way with the line of separation at about the middle. Great care should be taken in opening the flask that the plaster teeth are not fractured, also in packing the case

care should be taken that the deep spaces are filled with rubber.

As the type of splint just considered cannot, as a rule, immovably retain the fractured jaw in position, Dr. Kingsley aids the retention of the parts by the utilization of screws passed through the splint in the region between the molar teeth at the cervical portion.

Dr. Kingsley also invented a splint provided with arms of steel wire ⅛ of an inch in diameter, adjusted to come "out of the mouth when the splint is in position, passing back along the cheek on a line with the teeth." This splint covers only the inferior teeth, its superior portion articulating with the superior teeth for the purpose of mastication. Fig. 196 shows the model of the splint upon the articulator.

CHAPTER XXXII

ARTIFICIAL CROWNS

Definition.—Artificial crowns represent a system of replacing natural crowns that have become so seriously impaired through caries, or other causes, as to make restoration of the lost part by means of filling impractical. This system of replacement may also be utilized in cases of malformations, as, for example, the peg-shaped superior lateral incisor, which occasionally appears in place of the normal tooth; in cases of badly discolored crowns prominently exposed to view, and which may fail to respond to efforts at "bleaching," and in those cases where for any other cause it may be considered advisable to replace the natural crowns with artificial substitutes.

Classification.—Artificial crowns may be divided into two general classes, according to the method of attachment. The first class includes all crowns retained in position by means of a post or dowel. The second class includes all crowns retained in position by means of a band encircling the root.

Crowns of the first class are of two orders, first, those in which the post is baked in the crown, of which the Logan crown (Fig. 197) is a well known example; second, those in which the post is detached from the crown, but to which the crown is cemented for its retention, after the post and crown have been properly adjusted to the root.

The demand for the detachable crown has been steadily increasing, and at the present time it is used almost to the exclusion of the type of crown in which the post is permanently fixed to the crown in the baking process. A number of supply houses manufacture detachable crowns which resemble each other quite closely. The

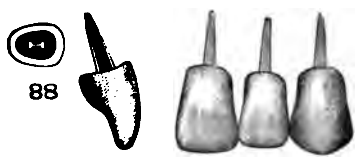


FIG. 197.—LOGAN CROWN.

FIG. 198.—DETACHABLE CROWNS.

Davis, the Justi, the Twentieth Century, the S. S. White are examples of this type of crown (Fig. 198).

In some instances, owing to the undue stress acting upon the crown, it becomes necessary to make provision against likely fracture of the root, in which cases the post and band are both utilized, the so-called post and collar crown in combining features of the crowns belonging to the two orders of the first class may be said to belong to a sub-order (Fig. 199).

FIG. 199.—POST AND COLLAR CROWN.

These several types represent the present evolutionary stage of crown work and are the modified forms of types first recorded in dental literature, when a form carved out of bone or ivory or a natural crown was mounted on a "pivot" of silver or gold, as described in Fauchard's work published in 1728. The introduction of the English tube teeth marked a distinct advance in this class of dental operations, but the wood pivot in use at this time proved inadequate for retention, also resulted in frequent fracture of roots through the absorption of moisture. A variety of forms

have been introduced since then, each designed to overcome the objections of the preceding forms.

The introduction of the Logan crown in 1885 marked a distinct advance in crown work, as it presented a form which had sufficient bulk of porcelain for strength, a concave countersunk base, which allowed the necessary grinding for close adaptation to the root without injury to the dowel. These improved features quickly led to a very general use of this crown, almost to the present day. With the addition of the collar whereby all the advantages which this affords are secured, without the disadvantages of the metallic backing, the Logan crown so constructed enjoys, at the present time, a very high position for usefulness and esthetic effect. The Land jacket crown, especially effective in overcoming the impaired appearance which peg laterals give to the face, and which are adjusted upon vital teeth, making devitalization unnecessary, may be viewed as a progressive step in the evolution of crown work. At the present time the *Spaulding crown* (see Jacket Crowns), an all porcelain jacket crown, possesses advantages over the Land crown.

So, too, with the hollow metal or shell crown with the porcelain facing. These crowns stand for a high esthetic development, as well as usefulness, and best meet the indications for which each form is fitted. The advent of the casting process has almost revolutionized both crown and bridgework. Former methods are now almost obsolete, and what changes may still follow its better utilization are now not to be defined. The selection of the form of crown to be used is usually determined by the *anatomical, physiological,* and *esthetic factors* of the particular case.

Anatomical Considerations.—This involves the posi-

tion of the root and the crown to be adjusted, determining the class of tooth to which it may belong; it also involves the study of the relation of the crown to the adjoining and antagonizing teeth. In other words, the anatomical considerations embrace the study of the *forces* acting upon the crown and root, the *proximal contact,* and the *occlusion.*

Each class of tooth is designed for a definite function in the performance of which it is subject to stress. In selecting and adapting the artificial crown sufficient resistance must be secured so that in the work for which it is intended it will not be displaced by the forces acting upon it. The *incisors* and *cuspids* are subject to stress which tends to force them outward. The *bicuspids* are subject to stress in a vertical, outward, and inward direction, the degree of which is determined by the area of contact with the antagonizing teeth, and by the length of the cusps. The *molars* are subject to a similar expression of stress as that acting upon the bicuspids, but the lateral stress is not as great, and but mildly exhibited in proportion to the accuracy of normal occlusion and the length of the cusps.

It is evident that the greatest natural resistance is in line with the long axis of the tooth; therefore, in adjusting an artificial crown this must be prominently in view, in order that the forces acting upon the root might be received in line with its greatest resistance, otherwise pathological conditions might develop terminating in loss of the root.

To establish *normal occlusion* and *articulation* is at all times an essential requisite. It reduces to the minimum the stress upon any one tooth. Faulty occlusion or articulation, as a rule, is quickly followed by pathological disturbances, severe in proportion to the degree

of its abnormality and the patient's susceptibility. In some instances abnormal occlusion may lead to those slow changes upon the root (hypercementosis) which frequently manifest themselves only after considerable enlargement has developed, followed by severe pathological complications, and terminating in loss of the root.

Equally important, with correct occlusion, is correct *proximal contact.* If the natural proximal contact is not restored the lodgment of food débris and bacteria soon proves a source of irritation to the interproximal tissues, quickly followed by the destruction of the alveolar wall and pericementum and the progressive loosening of the root; therefore, the anatomical relation of the crown calls for a correct proximal contact assuring protection to the interproximal and alveolar tissues.

Physiological Considerations.—In most instances of crown work either the pulp has been previously devitalized or devitalization is necessary before mounting the artificial crown. It may, however, occur that the natural crown may be so seriously impaired as to make restoration by filling, or inlay, impractical; and this may occur without exposure of the pulp, or any indication of its being pathologically involved. In some instances it may be most advisable to adjust the artificial crown without disturbing the internal physiological state of the root. When this form of treatment is adapted the same effective plan of sterilizing the infected tooth structure must be followed as applies to the treatment of a carious cavity. This applies with equal force to the protection of the pulp from thermal and other forms of irritation after the crown is adjusted.

The maintenance of the physiological state cf the pericementum is of the greatest importance. The im-

portance of forming correct proximal contacts toward this end has been previously discussed, also that of correct occlusion, but the mechanical features of the crown must also be considered in this relation. Ill-fitting shell or collar crowns will soon disturb the normal physiological aspects of the pericementum. In cases where the pericementum had been the seat of inflammatory changes its predisposition to recurring attacks must be recognized, and the possible irritation of a band encircling the root end and leading to pathological involvement of the pericementum might better be avoided. The existence of any pathological condition of the root must be corrected and a normal physiological balance secured before adjusting the artificial crown.

Esthetic Considerations.—These are assuming an increasing importance to which they are justly entitled. Greater attention is paid to-day to the avoidance of the unsightly appearance of gold than ever before. The form and shade of the teeth are very carefully studied that they may be faithfully reproduced in the artificial crown, in order that the harmony or "natural appearance" of the teeth might not be destroyed. The same thoughtful considerations are paid to many other details that the esthetic effect might be secured. In fact, these considerations enter largely in contributing to the final selection of the form and appearance of the artificial crown to be adjusted.

THE PREPARATION OF ROOTS

Almost from the inception of what may be termed modern crown work, writers have emphasized the importance of proper root preparation in relation to permanency in crown work. It is the essential prerequisite

whereby *success* is attained, and, although other factors may, and do, enter into causative relation for its final determination, not one is so preëminently conspicuous as a preliminary requirement as proper preparation of the root. Unfortunately, in some isolated cases apparent permanency is secured without due regard to the necessity of proper root preparation, and this is erroneously considered a successful operation. *Apparent permanency* in crown work is one thing; *success* quite another. The former is a matter of time alone and is necessarily relative. From one to five years may be regarded by some operators as a permanent operation, or a longer period may be required by others, and a crown in position after the fixed period is viewed as a permanent operation. However, during this period the retentive structures of the root may have become seriously impaired, directly due to a faulty crown, and in a short time thereafter the root is lost. This cannot be regarded as a *successful operation,* although it may be viewed as an apparently permanent one. In order to conveniently discuss the subject it may be considered under two headings, *therapeutic* and *mechanical.*[1]

Therapeutic Preparation of Roots.—This includes the probable procedure of pulp anesthetization or devitalization, and its removal. For this the reader is referred to Chapter XVIII. As to the advisability of devitalization or conservation, the reader is referred to Chapter XVII. These chapters will be found to contain the various views and conclusions bearing upon the subject. It may be here restated that, whenever the shape of the crown or its inclination necessitates excessive removal of tooth structure in order to properly prepare it for the reception of a shell crown, and if

[1] "American Textbook of Prosthetic Dentistry."

this procedure is necessary after the root of the tooth has been fully formed, it may be advisable to remove the pulp before adjusting the crown. The researches of Rhein, Bromell, and others have shown that in these cases, unless the pulp is removed, it is quite likely to suffer degenerative and necrotic effects due to the excessive loss of its protective tissues. But this should not be construed as an argument favoring the removal of the pulp *in every instance* in which crown work is practiced. Innumerable cases can be presented showing that the pulp retained its normal vital aspect for many years beneath shell crowns properly adjusted. The best results are obtained *when all the facts are carefully considered,* and the weight of evidence is relied upon to sustain one or the other mode of procedure.

The therapeutic treatment of the root also implies thorough sterilization of the canal and adjacent structure. To establish this the proper agents must be employed and sufficient time must be allowed. The presence of any pathological condition upon the root must be completely eliminated before proceeding with the crown. These are very important steps in crown work upon which rests in a large degree the success of the operation.

It may facilitate the treatment of the subject if we also consider under this heading the treatment of *hypertrophied gum tissue* which has occluded the margins of the root, *perforations,* and *fractured roots.*

Hypertrophied Gum Tissue.—The overhanging mass of gum tissue may be excised, and after the control of the hemorrhage by the use of styptics a piece of flexible matrix steel is tied around the root; over this the dam is adjusted, and the necessary treatment of the canal pursued. The steel band (any other metal may

be used) may remain in place until the canal treatment has been completed. In this position the metal band serves a double purpose. It securely retains the temporary stopping that seals the canal dressing, and it represses the gum tissue for the clear exposition of the root end.

If excision of the overhanging gum mass is not deemed advisable, it may be repressed by the use of temporary stopping, forced into the canal and flattened against the root end in a way to force the hypertrophied mass clear of the margins of the root. If the opening in the root is not sufficient for the retention of the temporary stopping, the suggestion of Dr. Wm. H. Trueman[1] will be found useful: "Should there not be sufficient concavity in the root to hold the stopping, a large-headed carpet tack may be pressed into the canal and the gutta percha wedge built around the post."

PERFORATED ROOTS.—It is only in rare instances that perforated roots are permanently retained, even after exhaustive therapeutic measures have been indulged toward this end. In view of this it is best in the beginning to consider carefully all the factors of the case, otherwise considerable painful effort will be fruitlessly expended. Many materials have been respectively acclaimed as possessing special therapeutic value when utilized for the closure of perforations. In the writers' judgment the attainment of success in these cases is more dependent upon the *vital qualifications* of the individual than the filling material. That some materials, such as copper amalgam, oxyphosphate of copper, tin, and gutta percha, may possess value beyond that of other materials is not denied, but the determination of the permanent retention of perforated roots is most

[1] "American Textbook of Prosthetic Dentistry."

likely a question of *tissue tolerance* for the presence of foreign material, its *healing* and *protective* power. When these *vital factors* are not marked it is not likely that the most painstaking efforts will end favorably; contrariwise, under the strong beneficial influence of these factors, even though less thorough methods for the success of the operation may have been practiced, it is our belief that success may be attained. Having concluded that the factors are favorable for success, the first step in the treatment is the sterilization of the perforated area. A rope of cotton saturated in the thymol-menthol-phenol compound is introduced, forcibly pressed into place, and the canal closed with temporary stopping. This is allowed to remain in place for several days to sterilize the infected area, also to clear the perforation of ingrowing gum tissue. When the patient returns the cotton dressing is carefully removed under aseptic precautions, and if the conditions are favorable a warmed cone of gutta percha preceded by chloro-percha is placed in the perforation; tin foil, copper amalgam, or copper oxyphosphate may be used. This is covered with a layer of cement to hold the material in place, and the canal closed until such time as may be selected for the construction of the artificial crown, the apical end having been previously closed by means of one of the methods discussed under Root Canal Filling.

FRACTURED ROOTS.—The fracture of roots may occur as the result of an accident, or of undue stress in mastication. To restore such roots to usefulness requires not only the application of effective methods of sterilization and considerable mechanical skill, but combined with this the underlying *vital factors* must be favorable. These are identical with those related to perforated roots, excepting that of tissue tolerance for foreign

bodies, and this may also be made to apply here, if we regard the fractured root as a foreign body. The *healing* and *protective power* of the tissues must be as great, if not greater, than that necessary for the retention of perforated roots, and, if absent, the greatest degree of mechanical skill will be found to be useless for their permanent retention. If the fracture occurs upon a molar tooth, and the vital factors appear favorable for conservation, the first indication is the sterilization of the area of fracture. The parts are sprayed with an antiseptic solution, dried with alcohol and blasts of warmed air; a drop or two of the modified phenol compound is dropped from a probe into the fracture; the two parts of the tooth are then pressed together, closely approximated, and securely retained in position by means of strong ligature wire. If a cavity exists it is flooded with the phenol compound and closed with temporary stopping, care to be exercised in introducing the temporary stopping not to disturb the relation of the apposed parts. The patient must be instructed not to masticate upon the tooth. The fractured tooth may now be closely studied to determine the character and method of permanently retaining the fractured parts. Fig. 200 illustrates a method utilized when sufficient structure remains; dovetail forms are cut in each side, into which a layer of cement is flowed and allowed to harden; the remaining portion of the cavity is filled with amalgam. When the amalgam has set the wire is removed and the tooth carefully prepared for a shell crown. After the tooth has been suitably shaped, a band is constructed of 22-k. gold, 30 gauge. The band when completed is cemented in place, and firmly holds the fractured parts without fear of displacement during

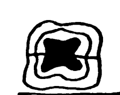


FIG. 200.

the construction of the crown which is fitted over the band.

In the anterior teeth a fracture may occur in a manner that makes restoration by filling fully satisfactory. This is the condition when the fracture is not deep, and after removal of the fractured portion suitable preparation for an amalgam filling can be made. The fractured portion is then restored in amalgam, and a collar crown adjusted, or a band with a floor soldered to it may be prepared, after the amalgam has set. This is cemented to place. To this a crown may be fitted and adjusted. In deep fractures extending beneath the alveolar wall the plan of restoration suggested by Dr. Cigrand is simple and effective. After sterilization of the fractured area, apposition and fixation of the fractured parts, as previously discussed, a circular groove is cut in the root, as illustrated (Fig. 201); into this a band is fitted and adjusted; this is ground down to the surface of the root and securely fixes the fractured portions. The wire now may be removed and the crown completed.

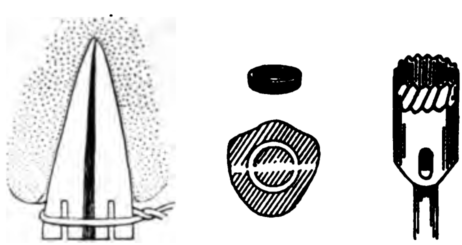


Fig. 201.—Dr. Cigrand's Method of Restoring Fractured Roots.

The casting process of late has been utilized in holding the fractured parts of a root in place. It enables the operator to easily construct accurately fitting inlays that take the place of missing portions of the root, as well as bands with the post attached, supporting the porcelain crown.

Technique.—Where the fracture does not extend beyond the alveolar wall, the fractured portion of the root

is removed. A perfectly clear field must be secured. If a hemorrhage has followed the removal of the fractured piece, this is controlled, and all evidence of blood removed from the field of operation. Gutta percha or temporary stopping is used to force away the gum tissue. A suitable porcelain crown is selected and fitted to the root. Iridio-platinum wire of proper gauge is fitted to canal and crown. Softened inlay wax is next pressed to place, chilled, and carved to the desired form; previous to this the post has been forced to place in the canal and the crown set upon the post. When the desired relation of the various parts has been secured the crown, post, and wax are removed. The porcelain crown is detached from the post, the wax model carrying the post is invested, and the casting prepared in the usual manner.

If considered advisable a band may be constructed in the following manner: A casting is first made to restore the fractured portion of the root. This is placed in position and a band fitted around the root. The inlay and band are waxed in position, removed, and soldered. The band and inlay are returned to position and beveled labially to a point below the gum margin. The floor and post are next fitted and attached to the band; when this is completed the crown is adjusted in the usual manner. In the *Cosmos* for 1903 Dr. Peeso describes a case of fracture to the apex of the superior central incisor root, occurring in practice; after the fractured parts were drawn tightly together by means of wire, the end of the root was trimmed for the reception of a narrow band. This was constructed of iridio-platinum and when completed cemented upon the root. The wire holding the fractured parts together was now removed, and the case treated similarly to the treatment accorded

any root for which a banded Richmond crown is constructed.

Mechanical Preparation of Roots.—The opinion of nearly all writers who by experience appear to be best fitted to pass judgment upon these matters appears to be that too little attention is devoted to the correct form the root or crown should be made to assume in its preparation for the reception of a crown; and to this, failure in crown and bridgework is most frequently due. No doubt this indictment, in a very large degree, is founded upon the truth. But, on the other side, is not the total disregard of the *vital aspects* of the crown or root also an error of practice, in many instances involving the root in a series of pathological phenomena, finally terminating in its loss? Examples are not lacking that confirm this conclusion. A safer mode of practice, no doubt, lies in the appreciation of the importance of what may be termed the *vital aspects* of the tooth or root, also of the great importance of grinding to proper form the crown or root to be crowned. The *prosthodontist* should be more of a *vitalist,* and the *vitalist* should be more of a *prosthodontist.*

The form which we desire to give the root depends upon the kind of crown to be adjusted. It has been previously indicated that two general classes of crowns exist, the *shell* or collar, and the *dowel* crown. In view of certain variations made necessary at times, because of the position or the physical state of the root, it will be convenient to consider the preparation of roots in relation to four classes of crowns: (1) the shell, (2) the shell with porcelain facing, (3) the band and dowel, (4) dowel crown without band.

Preparation for Shell or Telescope Crown.—This form of crown is usually constructed for the molar teeth,

and its correct adaptation is made difficult by the position of the teeth, and the amount of structure that in most instances must be removed to allow of a correct adaptation (Fig. 202).

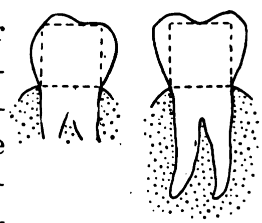


FIG. 202.

If through the action of caries or fracture the lost tooth structure extends beneath the gum margin, restoration by filling is essential before the band is adapted. This will prevent subsequent attack by the carious process by guarding against the lodgement of food débris and bacteria, materially lessens the liability to fracture of unsupported walls during the act of shaping the crown, and renders vastly easier the correct adaptation of the band. Amalgam is generally utilized for making the restoration. Where but little of the natural crown remains, an amalgam crown should be built prior to any attempt to fit the bank. In order to secure the amalgam it may be necessary to cement an iridio-platinum post in one or both canals. This effort is well repaid in the increased resistance it affords the crown, also in the protection it gives to the roots from caries.

In most cases where the gold shell crown is to be used, as previously noted, considerable tooth substance must be removed, especially upon the mesial and distal surfaces, where the contour is the greatest. It is essential that the walls be made parallel, or, what is better, converging very slightly occlusally from a point slightly below the gum line, i. e., about 1/64 to 1/32 of an inch below the normal gum line. (Some crown and bridge-workers object to even slightly converging walls in shaping a tooth for a shell crown, claiming that when the crown is adjusted upon a tooth so shaped, and force

exerted upon it, the edge of the crown is likely to curl up and form a shoulder.) It is well to emphasize again the importance of considering the vital aspects of the tooth, especially in regard to the pericementum, and that excessive grinding, or the impinging of a metallic band, may lead to irreparable injury of the retentive membrane of the root.

To facilitate the removal of all excess of tooth structure, a variety of stones, disks, burs, and enamel cleavers must be at hand, and in good form. Without these the work is unnecessarily delayed and made more annoying to both patient and operator. The mesial and distal contour are removed by means of a cup-shape disk, first cutting through between the teeth; the mesial contour is then gradually cut away with the face of the disk and the distal with the reverse side. A better plan is to cut through the contour; an examination is made below the gum line to determine the amount of structure to be removed; the disk is then placed at a point upon the occlusal surface, so that the entire contour is removed with one cut. A thin carborundum disk is used for trimming down the buccal and lingual surfaces. The thick-edge wheel may be used near the occlusal end to facilitate its removal, especially in lower teeth with a decided inward inclination. All sharp corners must be rounded particularly as approach is made toward the gum line, and for the desired distance beneath it. The cone, inverted cone, and small diamond disks will be found useful in this relation. The occlusal surface, usually the first to be cut down, is reduced by means of the heavier carborundum stones. Frequent examinations should be made to determine if the surfaces are being cut straight and even, otherwise the desired form may not be established, and enamel shoulders easily formed

where thin disks are employed for cutting may interfere with a perfect adaptation of the crown.

PREPARATION FOR SHELL CROWN WITH PORCELAIN FACING.—In preparing a case for the shell crown with porcelain facing, the principles of preparation are similar to those previously discussed, excepting that the buccal wall must be sufficiently reduced to accommodate the facing. The reduction of the buccal wall should not be made, however, until the other parts of the tooth have been properly prepared (Fig. 203).

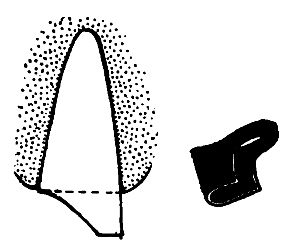


FIG. 203.

PREPARATION FOR BAND AND DOWEL CROWN.—In order to meet the esthetic requirements in the anterior teeth the natural crown, or what remains of it, must be cut down to a line so that the porcelain crown when adjusted will meet the gum line. The esthetic demands in the anterior position of the mouth must be carefully adhered to, and, together with correct occlusion and stability, are the chief factors to be considered in the construction of a crown. In cutting down the natural crown it is a better plan to allow a portion of it to project beyond the gum line until the band has been constructed. This gives a better opportunity to accurately fit the band to the root with a minimum of annoyance to the patient and injury to the gum tissue. The best plan of procedure is to insert a crosscut fissure bur into the cavity, at a point between 1/8 to 1/16 of an inch from the gum line, and cut through the dentin and enamel toward the center of the tooth, both labially and lingually if a cavity exists, and it usually does in these cases, both upon the mesial and distal aspects of the tooth; the bur may be inserted into both cavities and

the tooth structure cut away, working toward the center of the crown. In this manner sufficient structure is very readily cut away that the remaining portion can be snapped off with the fingers. This is a safer plan than cutting a labial and lingual groove into the crown and using the excising forceps, as recommended by some writers. With these a fracture may occur, or what is more likely, an injury to the pericementum. Bicuspids and molars are cut down by the use of dentate burs

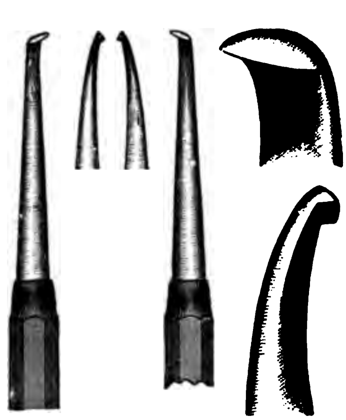


Fig. 204.—Dr. C. S. Case's Enamel Cleavers.

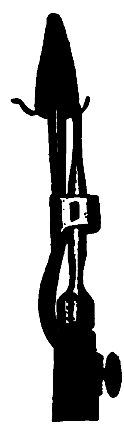


Fig 205.—S. S. White Root Reducer.

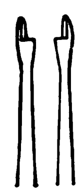


Fig. 206.—Dr. Stark's Root Reducers.

and carborundum wheels. A carborundum wheel may now be used to trim down the uneven walls to about 1/16 of an inch from the gum line. This projecting enamel must now be shaped to the form necessary for the reception of a band, viz., the greatest diameter of the root must be placed at the point reached by the outline of the band. To remove the remaining enamel, the enamel cleavers will be found effective (Fig. 204).

To establish the desired root form for the reception of the band it may be further necessary to use the "Root

Reducer'' made by the S. S. White Co., or those suggested by Dr. R. W. Starr will be found useful. Other forms are upon the market that can be advantageously utilized toward the same purpose. The band is now fitted to the root, and when the desired relation of band to root is established the projecting portion of the crown, which has been allowed to remain to facilitate the fitting of the band, is cut down, and the proper form given the base of the root. This is imperatively necessary in order to meet the requirements previously noted. Fig.

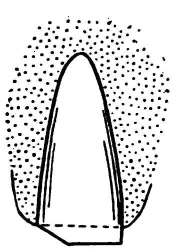


Fig. 207.

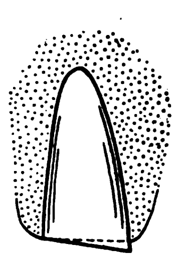


Fig. 208.

Fig. 209.

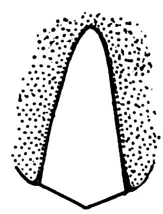


Fig. 210.

207 illustrates the form of the base of the root very frequently established. The labial bevel allows of the correct artistic effect, excepting, perhaps, that it might not afford sufficient space to avoid undue prominence at the neck. In this connection Fig. 208 shows a better preparation, assuring also every artistic and mechanical demand. This sloping form of the base of the root can readily be established with a carborundum wheel, after which the root-facers of Ottolengui are useful in preparing the root beneath the gum line without injury to the gum tissue (Fig. 209). In bicuspids and molars the surface of the root or roots is prepared flat. This form of seat for the artificial crown provides the great-

est strength, as the application of stress is in a direct line.

Preparation for Dowel Crowns Without Band.—Several forms of crowns without bands may be used, such as the Logan, of which the dowel is an *inseparable* part, the Davis, which has a *separable* dowel, and the plate and dowel crown, where the dowel and plate for the basal surface of the root are separately fitted and subsequently soldered, and to which, later on, a facing is added and attached with solder. Where it is intended to use the Logan or Davis crown, the sloping base form of the root, as indicated in Fig. 207, best meets the requirements. When closely adapted to the labial aspect of the root it affords a satisfactory esthetic effect, and the lingual projection, when the crown is adjusted, results in a self-cleansing joint.

When the plate and dowel crown is used the base of the root should be given the *saddle form* (Fig. 210), which provides greater resistance against displacement, and the accurate approximation of the plate against the root secures the prophylactic requirements.

PREPARATION OF CANALS

This implies enlargement of the canal to accommodate the dowel, which is selected according to the size of the root and requirements of the crown. The central incisors and cuspids admit of the use of a longer and heavier dowel. In no case should the canal be enlarged to a degree inviting fracture, in order to accommodate a heavier gauge dowel. The dowel should be made to enter the canal a depth equal to the length of the crown, which usually measures about two-thirds the length of the root. If it is found inadvisable to enlarge the canal

to the indicated degree to accommodate the dowel, as frequently occurs in the superior first bicuspid roots, two dowels may be used, one fitted in each canal, and, although shorter and of lighter gauge, the two dowels will adequately support the crown.

Having determined the gauge dowel to be used, the canal is enlarged to the desired depth to receive it. The Consolidated Dental Manufacturing Co. manufacture a twist drill in two sizes to correspond to the two sizes of dowels arranged for the Davis crowns, so that when the canal is drilled out with one or the other the corresponding size dowel is perfectly accommodated in the canal. A round bur may be used in place of the drill and the canal enlarged to receive the dowel. Care should be exercised in all cases not to perforate the root. It is best, in order to avoid root perforation, to occasionally examine the work of reaming the canal, and with the aid of explorers but little difficulty will be found in following its direction.

THE SHELL OR HOLLOW METAL GOLD CROWN

For many years this form of crown has occupied a most useful position in restoring to permanent and complete service natural teeth seriously impaired through caries or other causes; it has also been a potent factor in the development of bridgework, and, although at the present day, owing to the introduction of the casting process, its field of usefulness is considerably lessened, it nevertheless continues to occupy a prominent place among the operative procedures of restoring to usefulness many remains of teeth which, prior to the introduction of this form of crown, were consigned to the forceps.

The general efficiency of this mode of restoration

soon inaugurated an extensive period of misuse in placing this form of crown in conspicuous locations, and the thousands upon thousands of crowns to be found in the anterior portion of the mouth bear strong testimony to the lack of "esthetic sense" of both patients and operators. Time, however, has proved corrective of this form of abuse, and the present tendency is to a much better appreciation of the esthetic demands of artificial crown work.

Indications.—The gold shell crown should be placed upon the roots of *molars,* and occasionally upon the *second bicuspid* when this tooth is well hidden from view, and very rarely upon the *first bicuspid.* In this latter instance it may be used in the mouths of men when no other form of restoration appears advisable, or when the first bicuspid is to serve as an abutment for bridge-work, and where the use of the shell crown may be indicated to add to the strength of the bridge.

Methods of Construction.—The hollow metal or shell crown may be constructed by first adjusting a band to the prepared root, joining its two ends under heat, with or without solder, and to the prepared band cusps are soldered, the crown representing a *sectional* procedure. A second method consists of forming the entire crown by swaging a disk of 22-k. gold into the desired form, eliminating all joints and producing the *seamless crown.*

The Sectional Crown.—The sectional crown is the one generally employed, and offers advantages not possessed by the *seamless* crown, the most important of which is *better adaptation;* it also requires less time for its construction, and can be made stronger than the crown made after the seamless method. The advocates of the seamless method urge emphatic objection against the presence of the joints in the crown made after the

›ectional method, also in the presence of the solder nec-ssarily employed to bind the joints. These objections, owever, are more fanciful than real, and by far the reater number of operators construct the gold shell 'own after the method involving the presence of joints ıd the use of solder.

The first step in the construction of the crown, after e root or tooth has been properly prepared, is obtain-g an exact measurement of the root. This is usually cured by placing a loop of wire around the root, about 32 of an inch below the gum margin, with its ends stened in a dentimeter or hand-vise. The wire is isted taut, care being taken that in so doing it is not splaced. The wire measurement is removed from the ot, cut at a point opposite the twisted portion, and refully straightened out to give the linear size of the ot circumference. The width to be given the band ould also be marked, in order that a suitable piece of 2-k. 29 or 30 gauge gold can be cut. Dr. Goslee [1] recom-ends 28 gauge for the band, claiming that in the proc-ss of finishing and polishing the thickness is reduced, o that a 28 gauge is not too heavy. It is important in ll forms of restorations to have sufficient strength to esist the forces acting upon each particular restoration, rrespective of whether it is crown, bridge, or filling, and n relation to a shell crown this is amply provided for n a 29 or even 30 gauge band; furthermore, considering he reduced pliability of the heavier gauge, the com-ensating increase in strength of the 28 gauge metal for he band is not likely to prove sufficiently attractive for ;eneral adoption by the profession. Fig. 211 illustrates he manner frequently recommended of cutting the gold 'or the band. It is recommended that the *cervical* end

[1] "Principles and Practice of Crown and Bridgework."

of the band be cut the exact length of the measurement wire, the occlusal end wider, to afford the opportunity for most "artistic results" in regard to completely occupying the occlusal space with the contour of the crown.

Fig. 211.

Many crown and bridgeworkers object to this method of cutting the band, claiming that, as the band increases in circumference from the line of the root below the gum tissue, against which it is accurately adapted, and which represents the greatest sectional area of the root, or at least as great as at any other line, in festooning the cervical portion of the band it is quite likely that the original cervical line of the band will be destroyed; therefore, the portion of the band having a greater circumference than the original cervical measurement will be imperfectly adjusted to the root. Furthermore, if the band is cut as noted, and if the integrity of the cervical border as to circumference is preserved, when the crown is completed and adjusted, stress acting upon it may easily force it down further upon the root, owing to the increasing measurement of the band toward the occlusal end. If the sides of the root and remaining crown have been prepared parallel, the band is cut straight; if the walls have been prepared with a *slight* occlusal inclination, the band may be cut to correspond to the convergence, and when fitted to the root the end with the shorter measurement is adapted to the occlusal portion of the root. *The proper contour and contact is provided for by shaping the band and adding to it sufficient substance to yield the desired form.* The writers' method of construction has been to add the cusps after the band has been shaped, and the final contact form is secured by

means of a high-grade solder, which is flowed over the band in the desired position and amount to suit the case.

The desired length of the band having been cut, the two ends are brought evenly together and soldered with a small piece of 22-k. solder. Many crown workers prefer to make the joint by giving each end of the metal a slight *bevel,* of about the thickness of the plate; the ends are then overlapped the extent of the bevel and joined either by *sweating* the joint or with the aid of solder. This is generally regarded as being a stronger joint than the one soldered in the ordinary way by *apposing* the two ends of the band. Owing to the probability of subsequent discoloration the joint, if soldered, is usually placed in the middle of the lingual surface. It may here be in place to direct attention to the fact that the solder supplied by the dental depots and marked 22-k. solder *is not as marked,* but is intended for use upon *22-k. plate,* and does not contain more than *20 parts of gold.* It is better to use at the first soldering a solder that actually contains *22 parts of gold,* in other words a 22-k. solder, so that at the subsequent soldering, if any fear is entertained as to the repeated use of 22-k. solder, a lower grade may be used, but one that is not as low in grade as is necessary when the karat of that first used is below 22.

The two ends of the band having been united, it may now be placed upon the root and forced toward the gum line in order to conform the band to the shape of the root, but under no circumstances should it be forced at this time below the gum line at any point. This results in unnecessary irritation and injury to the tissue. Having conformed the band to the shape of the root, it is removed and trimmed to conform to the line of the

gum tissue surrounding the root. When this step in the procedure is completed, and the cervical portion of the band is perfectly smooth, and the edge given an inward bevel, it is again placed upon the root and forced to position. If the operation to this step is satisfactory the band is removed and the occlusal edge trimmed down to allow for the placement of the cusps; it is then made smooth and properly contoured. If, as has been previously noted, the full contour and contact cannot be secured by shaping the band, owing to the manner in which the edges of the band have been cut, the occlusal edge of the band is shaped as close to the desired contour as possible; the cusps are then added to the band, and, when this portion of the technique is complete, *the full contour and contact is formed by flowing a high karat solder in the desired position and form.* While this method of forming the contour may be open to the objection of the use of an excessive quantity of solder and the subsequent discoloration that follows, however, it seems to the writers that this is less serious by far than an incorrectly adapted crown, which is quite likely to follow in the hands of the inexpert when the band is cut with a greater occlusal than cervical measurement. Various methods have been suggested for adding the cusps to the band. Probably the most accurate results were secured, up to the time of the introduction of the *casting method,* by securing an impression of the antagonizing teeth correctly articulated with the band. The casting method has simplified this part of the construction of a shell crown *without sacrifice of accuracy:* therefore, before long it is destined to take the place, excepting, perhaps, in isolated instances, of all other methods of cusp addition for the completion of the crown. The following *three methods* for cusp construc-

tion will be here described: (1) the impression method; (2) the solder method; (3) the casting method. These not only meet all the requirements, but make useless many of the mechanical aids that from time to time have been introduced for cusp construction.

(1) *The Impression Method.*—When the band has been fitted and trimmed as desired, it is filled with wax before taking the bite. This aids in its removal from the mouth, also in its adjustment upon the model. Wax is softened in sufficient quantity that the form of two or three teeth on each side of the crown can be included in the bite. A plaster impression is next taken, including the same teeth as those of the wax bite. This is varnished, the model poured, and when sufficiently hard separated, the bite adjusted, and the model with bite wax in position mounted upon a crown articulator. When the wax is removed the plaster teeth are carefully varnished, and when dried plaster is poured into the band and the articulator closed. The importance of having the teeth adjacent to the band reproduced in the impression and bite is now better appreciated; it serves to correctly occlude the antagonizing teeth. When the plaster has set the articulator is opened, and the band with its impression of the occluding teeth removed from the model, in a manner that the guide to its accurate return is not destroyed. The band may now be cleared of adhering particles of plaster, and the impression within more clearly defined as to cusps and sulci, without destroying the correct occlusion. It is also well to trim the plaster cusps sufficiently to expose the edge of the band, so that when the gold cusps are formed they will just meet the edge of the band. If this is not done the gold forming the cusps will overlap the band, and it will be necessary to use considerable solder to make a per-

fect joint between cusps and band. A molding ring is next filled even to its edge with moldine and the plaster cusps, after being dusted with lycopodium, are pressed into the moldine until an impression of the edge of the band is secured. The band is now carefully removed from the moldine, the mold dusted with lycopodium, and the die formed by pouring Watt's metal into the mold

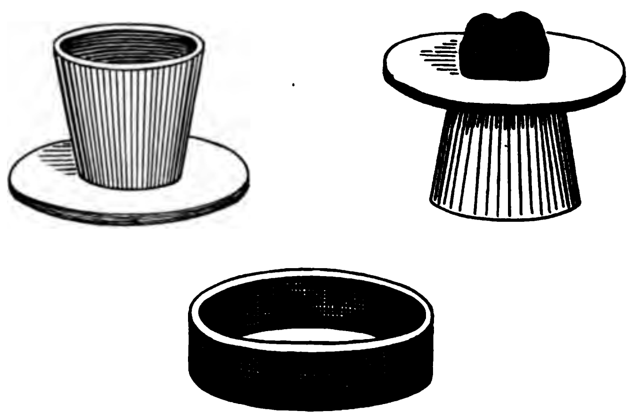


FIG. 212.

through a casting cup. Fig. 212 illustrates the molding ring, casting cup, and cusp button. The casting cup has a small opening through the center of its large circular base, and it is at this point that the cusp button is cut or sawed from the cup after the metal has cooled. The counterdie may now be prepared by pouring a lower fusible alloy over the cusp button, which is arranged upon a block of moldine within the ring, or a simpler method may be pursued with sufficient accuracy of result to justify its use, and that is by softening *metallin compound* and forcing it over the cusp button, a counterdie may be prepared in a few moments that will answer all practical purposes. Another method of forming the

gold cusps, adopted by a number of operators, consists of forming the cusp button as previously indicated; when formed a piece of 24-k. gold plate 36 gauge is annealed and swaged with a round end instrument, or the rubber end of a lead pencil admirably answers the purpose, over the cusp button, until the exact form in the gold is produced. The inner side is filled in with 22-k. solder, forming solid cusps with 24-k. gold plate on the outside. When using the heavier gauge plate, such as 29, or the 28 gauge recommended by Dr. Goslee,[1] the counterdie must be formed from a fusible alloy, in order to secure the strength necessary to properly swage the heavier plate.

When the cusp form is satisfactorily reproduced in gold the surplus material is cut away to the line indicating the outline of the band, and filed smooth; the band is now freed of its plaster contents, accurately replaced upon the articulator, and the interior filled with wax to support the gold cusp form. This is placed in its proper relation to the band, and the articulator closed to test the occlusion; if satisfactory, the cusp form and band in proper relation to each other are wired, or, what is usually more satisfactory, placed in the pliers designed to hold the two parts together (Fig. 213), and the crown completed.

Fig. 213.

The Solder Method.—This method of cusp construction may be utilized in instances where the saving of time is an important factor. Excellent results may be obtained by means of it, providing the necessary ex-

[1] "Principles of Crown and Bridgework."

perience has developed a proficient technique, and an accurate knowledge of the forms of the teeth has been acquired.

After the band has been accurately fitted and trimmed, as previously discussed, a piece of 24-k. gold plate, 36 gauge, is soldered straight across the occlusal edge of the band, and trimmed even with its outer surface (Fig. 214). A heavier gauge plate may be used. Upon this base 22-k. solder is flowed to build up the cusps to the correct form of the tooth and to restore the occlusion.

FIG. 214.

During the operation of making the cusp restoration the band is repeatedly tried in position to determine its various relations and form, and when finally completed should meet all the requirements of tooth form, contact and occlusion. The casting method may now be applied in forming the cusps for the band, with a great saving of time in comparison to the swaged method, and with equal effectiveness.

The Casting Method.—The advent of the casting process has made many innovations in the practice of crown and bridgework, in many instances entirely superseding former methods, and before long, very likely, finding greater application in the construction of artificial crowns and bridges by an increasing number of operators.

As with the former methods, the band is first fitted to meet all requirements. With the band in position inlay wax is softened, placed within the band, and the patient instructed to bite into it, care being taken that the occlusion is correct. The wax is chilled and carved to suitable form. The band with its contained wax is removed from the mouth, the surplus wax cut away from

within the band, also carefully trimmed upon all surfaces to the edge of the band, and any further carving upon the occlusal surface to better delineate cusps and sulci may now be performed. If desired the wax impression may be removed from the band, and that portion that occupied the space within the band may be cut away, but in no way should the wax be treated that its exact relation to the band is altered or destroyed. If any doubt should exist as to a possible distortion of the wax form, the band may again be adjusted upon the root, the wax model placed in position, and the patient instructed to bite. A careful examination is made to determine if all the requirements are satisfactory; if so, the wax is cautiously removed from the band, invested, and a casting made as for an inlay. When completed it is tried in position, and the case completed in a similar manner to the swaged method previously considered.

THE SEAMLESS CROWN.—The advocates of the *seamless crown* give undue prominence to the objections that may be made against the presence of joints and solder of the *sectional crown.* They also claim greater artistic effects in the use of the crown constructed after the seamless method. These objections are not well founded, and have no practical significance. This is particularly true concerning the artistic effects made possible at the present time in the utilization of the *casting process* in the construction of the cusps. On the other side, it must be said that the accuracy of adaptation of the seamless crown is not equal to that of the crown made after the sectional method; therefore, if every other contention in favor of the seamless crown could be convincingly sustained, the fact that the method of its construction is almost sure to result in an adaptation to

the root less perfect than can be secured by the other method of construction, is sufficient ground for a decision in favor of the sectional crown.

Technique.—The root having been prepared, a band is shaped from 32 gauge copper plate, the size of the measurement of the root, and its ends soldered. As the accuracy of the finished crown depends upon the closeness of adaptation of the copper band, it should be perfectly adapted to the root. The buccal and lingual portions of this band are cut out as illustrated in Fig. 215. This allows forming the plaster, which later will occupy these parts of the band, into any desired contour for reproduction in the finished crown. The proximal surfaces are contoured to full contact with the adjoining teeth. The band being properly adjusted, the bite and impression are taken. The model is next prepared, to which the wax bite is adjusted, and both mounted upon an articulator. Removing the wax and separating the antagonizing teeth, the plaster teeth are varnished, the band and space filled with plaster, and the articulator closed.


Fig. 215.

When the articulator is again opened, the plaster is trimmed to the precise form it is desired to give the crown. Care should be taken in trimming the plaster not to expose the edge of the band, as is done when the cusps are swaged. The band and its contained plaster model are now cut from the working model, allowing sufficient of the old model to remain to provide a base for the band and plaster form (Fig. 216). This facilitates handling, and secures suitable dimensions for the die. It is also advisable to trim the plaster in contact with the band in the cervical region so as to expose

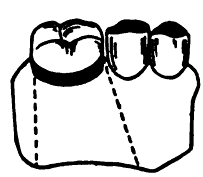


Fig. 216.

the thickness of the metal. This line is reproduced in the die, and, after the crown is swaged, indicates the exact line to which it should later be trimmed. The plaster model is now thoroughly dried, dusted with lycopodium, and set upon a cake of moldin; over this a divided molding ring, or section flask, of which several designs are upon the market, is adjusted. A piece of cardboard is placed in the grooves in each side of the flask, and allowed to extend toward the plaster model, but should not touch it at any part. The purpose of this is to facilitate the separation of the die, when cast, into two parts. A fusible alloy is next melted and poured; when cooled the flask is opened, the cardboard removed, and by inserting a chisel into one of the grooves formed by the cardboard, and striking it a light blow, the die is divided into two parts. The model is now removed from the die, the two parts of which are carefully apposed, and securely placed within the flask. The seamless shell is now formed by driving a disk of 22-k. gold of about 31 gauge through the openings in the steel plate (which is a part of each "outfit"), with the drawing punches, until the size is formed that can be conveniently forced into the die. Frequently annealing the gold and oiling the openings in the plate will materially aid in forming the shell. Oiling the fusible die will also assist in swaging the shell into the crown form. The proper size shell being formed, it is filled with moistened cotton, or red gutta percha base plate (other substances may be used), and placed within the die. By means of a blunt piece of wood and a few light blows, the shell is made to take the form of the die. When this has been accomplished the flask is opened, the crown removed, trimmed to the cervical outline marked on the band, and finished.

The crown is now placed in position, and, if found considerably enlarged, which may occur in the swaging process owing to compression of the die, the difficulty may be corrected by swaging a new crown. The gold crown is cut in two, placed in the die, the flask adjusted, and a new shell or blank swaged to form within the old crown.

Instead of constructing the seamless crown by swaging a shell to the form of a die, as above outlined, the reverse process may be followed, and the shell may be conformed to the lines of a metal reproduction of the plaster model by means of compression. In this process the metal is not stretched, as in the former, where the resultant crown frequently must be reinforced in order to withstand attrition. The distinctive disadvantage of this latter method of forming a seamless crown, i. e., by the method of compression over a metallic reproduction of the plaster model, lies in its being necessarily enlarged as it is drawn over the metal form. Furthermore, in the act of swaging the gold is very apt to overlap; to avoid this great care and patience are necessary. Greater accuracy in the final adaptation of the crown, when constructed after this process, is secured if the original copper band is cut away from the plaster tooth. This, of course, allows the crown constructed upon the metal form produced from the plaster model without the band a closer adaptation to the root. When the copper band is cut away the plaster is smoothed. a cervical outline is next distinctly marked upon the plaster to be reproduced upon the crown, and to act as a guide to its proper trimming. The plaster model, after being varnished and dried, is set within the molding flask and the cardboard adjusted, as in the previous method. A thin mix of plaster is now poured

over the plaster tooth, in much the same manner as the molten alloy is poured in the former method. When the plaster has set, it is broken into two parts by inserting an instrument into the opening created by the removal of the cardboard. The model is removed, the two parts of the broken plaster are properly adjusted to each other, and replaced within the flask. After being dried, a low fusible alloy, one that melts at the boiling point of water, is poured to create the form of the withdrawn plaster model. Over this metal form the shell is swaged until the form of the crown is secured. As previously intimated, care must be exercised to prevent knuckling of the metal during the swaging process. When the gold crown is formed the metal die within is removed by placing it in boiling water. The crown is completed in the usual manner.

The Shell Crown for the Anterior Teeth.—In the foregoing pages we concluded that the shell or gold crown, because of its conspicuousness, should rarely be placed forward to the second bicuspid. This is axiomatic of correct practice. Under certain conditions, however, it may be necessary to adjust it upon the anterior teeth. These conditions obtain in the mouths of men past middle life where the natural teeth have suffered great loss of substance through abrasion. Restoration of the anterior teeth may be made by means of the shell crowns, providing that the bite cannot be opened by adjusting shell crowns upon the posterior teeth, or in the use of inlays, thus admitting of the "building up" of the occlusal edge with *foil,* which form of restoration is to be preferred, if it can be accomplished. The shell crown may be placed upon the cuspid tooth, when this tooth is to serve as an abutment for bridgework, and where the factors strongly argue for the form of retention possess-

ing greatest strength, and where its presence in the anterior portion of the mouth, under conditions similar to those admitting of its use in the former instance, is not glaringly offensive to the esthetic sense.

Technique.—The tooth is prepared, as previously indicated in the construction of the shell crown for the posterior teeth, so that the greatest diameter is placed just a trifle below the gum line; a piece of 22-k. gold of 29 or 30 gauge is cut the length of the wire measurement, and a little wider than the length of the crown of the tooth. The gold is annealed and made to conform to the root; when correctly adapted its two ends are joined with solder or otherwise, and cut down on the proximal surfaces to conform to the gum outline. When this step in the procedure is completed, the band should be perfectly adapted to the root and accurately follow the cervical line, as illustrated in Fig. 217. The length of the crown and the lingual form are now outlined upon the band, and the metal cut to these lines (Fig. 218). The contour of the crown is next formed, and when satisfactorily established a piece of 22-k. plate, the same gauge as the band, is conformed to the lingual portion of the band and soldered to it. The surplus is trimmed away and the crown finished in the usual manner. This is the simplest and safest method of constructing the shell crown for the anterior teeth. Other methods may be followed, such as constructing a band of copper for the root, and, when adapted, an impression is taken including two or more of the adjacent teeth. A model in fusible alloy is prepared. The band is removed from

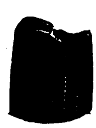


Fig. 217.


Fig. 218.

the model clearly indicating the cervical lines. Upon the model in alloy the crown is constructed following the procedure previously indicated. The crown may also be constructed by swaging upon dies secured through moldin of both the labial and lingual surfaces. The two halves are swaged, suitably trimmed, and soldered. The seamless system may also be followed, and is similar to this method of construction for the posterior teeth. But, as previously stated, the simplest and safest method is that of constructing the crown directly upon the tooth. The use of the ready-made crowns supplied by the dental houses cannot be too strongly condemned; in their use crown and bridgework is degraded, and the great loss of roots and teeth in countless instances can be directly attributed to the pathological sequences following their adjustment upon perfectly normal roots.

The Shell Crown with Porcelain.—The principle of retention of the shell crown may be adopted for a form of crown for the anterior teeth, where it is considered expedient to retain the vitality of the pulp and conserve a portion of the natural crown to which the attachment is made. A porcelain facing is subsequently added to the band to meet the esthetic requirements of the case. This may occur in peg-shape laterals, in excessively abraded teeth, or, in very rare instances, an irregularity may be seemingly improved by constructing a gold crown for the irregular tooth, and attaching thereto by means of heavy iridio-platinum wire, a facing properly aligned with the regular teeth. Fig. 219 illustrates a suitable condition for this method of correction as recommended by Dr. George Evans. The combination of band and porcelain may also be utilized for the posterior teeth, and, if the factors are favorable,

i. e., if the stress of mastication is not likely to result in fracture of the porcelain tooth, this form of crown for the posterior teeth is superior to the all-gold crown.

Technique for the Anterior Teeth.—The tooth to be crowned must not only be shaped for the proper reception of the band, similar to those cases where the all-gold crown is used, but the natural crown must be reduced in size to properly accommodate the facing. When this step in the technique is completed, a band of 22-k. gold 29 or 30 gauge is adapted to the root and soldered. Labially the band is cut out to follow the lines of the natural crown, and to admit placing the facing at the gum line. Lingually the band is allowed to extend to the line of occlusion. While in position upon the root wax is placed within the band and the bite taken; the impression is also secured. When the model is prepared a facing is ground to fit, its lingual surface is covered with a piece of 24-k. gold 36 gauge, or thin platinum may be used; this is carefully trimmed and smoothed along the edge of the facing, so that when the facing is placed in position the backing meets the edge of the band. The band is next loosened from the model, replaced, and the facing waxed to it in its proper position. The case is later invested and soldered.

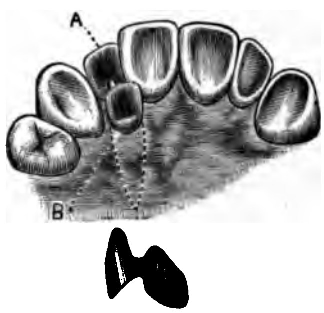


Fig. 219.

For the peg laterals the jacket crown introduced by Dr. Land, now known as the *Land jacket crown,* is a more esthetic mode of restoration than the crown previously described, and, when the conditions admit of the use of a satisfactory bulk of porcelain necessary for *strength,* superior results may be obtained in its use.

This crown is constructed as follows: The natural crown is reduced, as previously discussed. A piece of 36 gauge platinum is cut to the measurement of the root, and wide enough to extend to the occlusal edge of the natural crown. The metal is adapted to the root, and the ends soldered with pure gold or platinum solder. When the cervical form of the band has been satisfactorily produced, the band is cut both upon its mesial and distal sides from the incisal edge well toward the cervical end. This facilitates conforming the band to the shape of the natural crown; this done, the surplus is cut away and the joints soldered. The band is returned to the root, the platinum roughened to better hold the porcelain which subsequently will be fused upon its surface, and an impression taken including the adjoining teeth. When the impression is withdrawn, the interior of the band is coated with wax to facilitate its removal from the model, and the model poured. A suitable porcelain facing is selected and ground to meet the requirements. It may be necessary to grind away the projecting pins and considerable of the tooth, leaving only a thin veneer, before the facing is properly adjusted to place. When this is necessary considerable care must be exercised that the facing is not drawn out of position during the fusing process. In order to avoid this it is best to apply the porcelain body in small quantities, each only carried to the *biscuit bake;* the body attached to the facing will hold it in place while more body is added between the facing and cap, and then fused together in the final bake. If the pins are not ground away it is recommended,[1] after adjusting the facing, to solder the pins to the cap before applying the porcelain, thus securing the crown in position, and avoiding the risk of its displacement

[1] Goslee's "Principles of Crown and Bridgework."

by the expansion and contraction of the porcelain. Fig. 220 illustrates the construction of this form of crown.

Fig. 220.—The Land Jacket Crown.

Another form of jacket crown which appears to be superior to the Land jacket crown has been introduced by Dr. E. B. Spaulding of Detroit, Mich. In this crown the platinum cap is removed prior to its permanent adjustment, resulting in a porcelain shell, affording greater strength than can be claimed for the Land crown, as well as unlimited possibilities in the esthetic and other requirements. The following is Dr. Spaulding's description of his method:

"The following process in detail for preparing the tooth, forming matrix, adapting veneer and fusing, I have adopted after considerable experiment and practice, as being the most simple, direct, and accurate means of producing a uniformly successful result. Let us first look at Figs. 1 and 2, Plate A, to get a better idea of what it is we wish. Fig. 1 shows a tooth properly prepared, enamel removed to the shoulder at the gum line, and dentin more or less cone-shaped. Its shell of porcelain is seen above, and when in place on the tooth fits as nicely as shown in Fig. 2, joint everywhere flush and almost, if not quite, as tight as an inlay joint.

"When a tooth in the mouth calls for treatment in this manner it is usually because of deficient enamel; consequently there is not the large amount of enamel to remove which would be found on a normal or perfect tooth.

"We will imagine an upper central incisor, the enamel of which is lacking on the labial surface from erosion, and we desire to remove the remainder of the enamel preparatory to making a porcelain jacket. We first take a 7/8-inch thin separating carborundum disk (rubber and carborundum), mounted in the engine hand piece and, being revolved at a high speed and kept wet with a stream of water from the syringe in the hands of an assistant, the mesio-approximal surface is removed in the manner indicated in Fig. 3. Commence at the cutting edge and move the disk toward the cervix. Where the disk is stopped at the gum, a shoulder is left, such as is desired around the entire tooth when the preparation is completed, and this should be at, or slightly below, the gum line.

"The disto-approximal surface is dressed in like manner and the remaining enamel removed from the labial and lingual surfaces by means of a 1/2-inch knife-edge carborundum stone (not disk). This removes the enamel from four sides and leaves four corners to be rounded off by means of the disk again, approached at different angles.

"Up to this point we have paid little attention to the shoulder, except as left by the disk on the approximal surfaces. By the use of the smallest inverted carborundum stones on the market (3/16 inch, No. 184, see Smith and Sons) mounted with shellac on an old bur, the shoulder on the labial surface is partially dressed, and a similar stone mounted on a right angle hand piece bur, accomplishes the same result on the lingual surface. The shoulder is finished and receives its definite line by means of sharp wheel burs. Let the use of *new, sharp* knife-edge stones and *new, sharp* wheel burs be emphasized, for a dull bur and a dull stone both cause pain.

The point or cutting edge of the tooth is shortened and the whole treated with a few quick touches with a sand-paper disk to smooth and complete the preparation of the tooth to receive the matrix. For convenience, we will call the prepared portion of the tooth the conical portion.

"In preparing the tooth in this manner we have not encroached upon the pulp at all, and what would seem to be an excruciatingly painful operation is really little more annoying than the preparation of cavities, as we do almost every day.

"The first step in forming the matrix is to obtain the circumference of the tooth *over the shoulder and under the gum.* This is done by means of a dentimeter, or by a thin strip of copper or other metal pinched about the tooth. This measurement is more conveniently taken before the tooth is prepared and the shoulder formed.

"Now, cut a piece of inlay platinum (1/1000 inch) 1/16 inch longer than the measurement taken and ⅜ inch broader than the length of the conical portion of the tooth from the shoulder to the point. This rectangular piece of platinum, as shown in Fig. 4, is now changed by cutting off the angles 'A' and 'B' to the form C, E, F, D, Fig. 5. The edges C, E, D, F, are lapped 1/32 part of an inch, the cone-shaped instrument, Fig. 6, assisting to bring the edges of the platinum in absolute contact, which is then firmly held in the pliers, Fig. 7, while the end of the seam is soldered with a very small particle of pure gold. As soon as part of the joint is soldered, loose the pliers and grasp the platinum on the side opposite to the seam, and if the edges are in absolute contact there is sufficient gold present to complete the union of the edges when the heat is again ap-

plied. The very smallest particle of gold should be used in soldering.

"Fig. 8 (plate B) shows the platinum cone, which is 1/32 inch larger at its base than the circumference of the tooth, and when placed over the tooth will slip over the shoulder and under the gum.

"The advantage of the cone is now shown in Fig. 9, for, the farther over the tooth it is carried, the tighter it becomes at the points G and H, where the fit of the matrix *must be exact.*

"Now, with a piece of No. 27 gauge copper wire in the dentimeter, a loop is placed about the cone (Fig. 10) and is alternately tightened by twisting, and carried toward the shoulder with a burnishing instrument until the wire has been worked carefully into the angle between the shoulder and the conical portion, carrying the platinum with it and shrinking it to the tooth. During this stage of the process the forefinger of the left hand has been held tightly on the point of the cone to keep it firmly in place. The wire is now tightened as much as possible without breaking it, and serves to hold the platinum firmly while the next stage of the burnishing is done.

"The burnishing instrument (Fig. 11) is made from a bone handle of a mouth mirror, and its shape is seen in the illustration. With the thumb and forefinger the platinum is pinched to the conical portion, aided by the burnisher and narrow-nosed pliers, or tweezers, so that the surplus is carried to the approximal sides (Fig. 12, I and J, Plate C). Now trim the surplus, leaving an extension of about 1/32 to 1/16 of an inch, which is lapped over and burnished down smoothly on the sides, but not on the point, as in Fig. 13. The wire is now removed and the platinum thoroughly burnished over

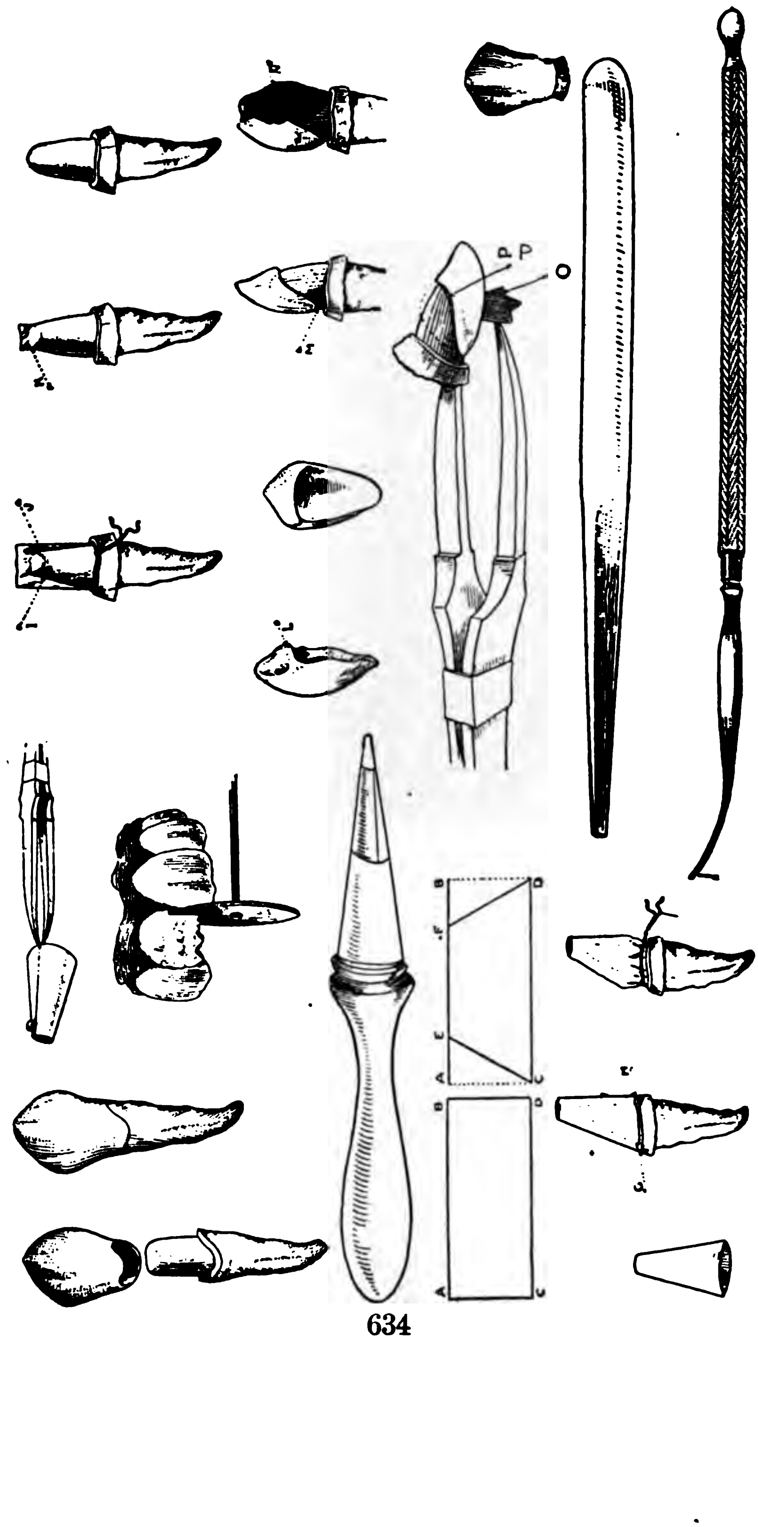


FIG. 221.—THE SPAULDING CROWN.

the shoulder and into the angle, using besides the bone burnisher the small 'V' shaped steel burnisher (Fig. 11, A). The unburnished point of the matrix (K, Fig. 13) is now grasped in the pliers and the matrix removed and replaced once or twice to make certain that it does not bind at or below the shoulder. This done, the point is lapped and burnished, as were the sides, and the matrix is completed (Fig. 14).

"The next step is the preparation of the veneer, which forms the labial portion of the jacket. The proper shade and shape are preferably selected in a vulcanite tooth on account of its shoulder (L, Fig. 15), which assists in adjusting to the matrix. The back and pins are ground away until a very thin veneer is left, as in Fig. 16. This grinding is not so laborious a task as might be supposed if small knife-edge carborundum stones are used, together with the little inverted cone stones (No. 184) previously mentioned. The stones should be kept thoroughly wet during the grinding, and the veneer tried on the matrix, which is in place on the tooth, from time to time, in order to bring it to proper alignment with the other teeth. When it assumes the desired position, the cervical end of the veneer is shortened, so that it does not touch the shoulder, as at M (Fig. 17). It is now thoroughly washed to remove all particles of carborundum, and adjusted to position, where it is held with a finger of the left hand while a small ball of wax (gutta percha base plate wax preferred) is warmed and pressed against the lingual portion of matrix and veneer, imbedding them so that they are held in their proper relation (Fig. 18). Usually the veneer and matrix are held firmly enough by the wax, so that they are removed from the tooth together; but, if they should separate, the wax and veneer remain together and the matrix is

readily teased off the tooth and placed in its position between the wax and the veneer.

"Having a pair of tweezers, with sliding band for locking them, place a small piece of vulcanite rubber on one beak; insert the bare beak within the matrix and let the one protected with the rubber rest on the outside of veneer; close and lock. Remove the wax, and the matrix and veneer will be found to be held firmly in their relative position, as is shown in Fig. 19.

"The gutta percha base plate wax (N, Fig. 18) is not excessively sticky, and is black, and if any particles remain they are readily seen and removed before applying the porcelain body. O, Fig. 19, shows how the rubber is utilized to prevent beak or pliers from slipping on surface of veneer.

"The body is first applied on one side, only at the point indicated by the arrow P, in Fig. 19, and, being mixed rather thin at first, the tweezers are thoroughly jarred by drawing across them a rough-handled instrument until the moisture is seen to appear on the opposite side of the matrix, corresponding to where first applied. This shows that all the air between the matrix and veneer has been driven out by the moist body. Now additional body is applied in a much drier state, until the matrix is covered only so far as indicated by the dotted line in Fig. 19. In no case let the body reach the shoulder before the first fusing. The moisture being thoroughly jarred out, the work is ready for the first fusing. Remove the pliers, when the matrix and veneer will be found to be held firmly by the body so that the whole will stand upright, resting on the base of the matrix, and is carried on the slab into the furnace in this manner. At the time of first fusing the moisture should be dried out slowly, for if heated too rapidly the moisture

between the matrix and veneer will form steam and throw the veneer off. Let the work be slowly moved into the furnace, so that the veneer faces and receives the heat first.

"After fusing, place the united veneer and matrix on the tooth and the portion of the matrix over the shoulder of the tooth is again burnished to correct any possible changes which may have taken place during previous handling. Removed, and again washed, the matrix is completely covered with body flush to the shoulder line and built up and carved on the lingual and approximal surfaces, as the case may require. There may be as many fusings as the operator deems necessary to produce the desired result. How nearly the finished article resembles the shape and shade of a natural tooth must depend upon the operator's knowledge of tooth anatomy, his artistic eye and his ability to manipulate porcelain. Fig. 20 shows shell complete before matrix is removed. The matrix is removed much as it is from an inlay, by pulling away the sides with a pair of tweezers, care being taken not to let them slip and strike the edge of the shell and chip it. If the matrix clings very closely up in the point, it is readily detached with a small bur in the engine (see Figs. 1 and 2 or shell complete, with matrix removed).

"Before setting in place with cement, the inside of shell is etched with hydrofluoric acid, to provide a surface for the attachment of the cement. The dentin of the tooth should be varnished with a good cavity lining before cementation. The cement should not be mixed too thin, neither should it be so thick that much force is necessary to carry the shell to place, as it might be fractured in this way.

"A question which will readily suggest itself is,

does not the grinding out of the porcelain tooth to form so thin a veneer change its color, and also, will not the cement change its shade when set in place? That is answered by saying that the portion of the porcelain tooth ground away is usually yellow, of a varying shade, and the characteristic blue, brown, or other shade is retained in the veneer, and when a cement is chosen, a yellow is selected, which will replace the underlying yellow ground away. It is possible to influence the shade of the shell somewhat in the choice of a cement.

"By the completed and cemented shell we have a live and healthy tooth, thoroughly protected from injurious external influences. Experience teaches us that a tooth is never so comfortable with a metal filling or metal crown as it is with a porcelain inlay or porcelain shell. It is more artistic and natural than any other style of crown. No other crown has so flush and tight a joint, and the irritation of the gum, characteristic of band crowns, is entirely absent.

"Lastly, it has strength to withstand severe use in the mouth. As a shell uncemented it is frail, but when thoroughly supported by cement it has the endurance almost of the natural enamel.

"The porcelain body used in constructing these shells should be of a very high fusing body, or what is termed block body, or porcelain tooth body. While the consolidated high fusing body will answer nicely, block body may be prepared by taking the bicuspids and molars of a set of diatoric (pinless) teeth and pulverizing them in a wedgewood mortar. One tooth at a time is taken in the mortar, and when it is fractured into a number of small pieces they are emptied upon a sheet of white paper and an assortment made, separating the pieces composed of the clear blue, or characteristic color of

the cusps of the tooth, from the remaining yellow, which forms the bulk of the tooth. The blue is powdered separately from the yellow, and the amount of each obtained from a set of four molars and four bicuspids gives us sufficient body of these two shades to last some time. Four shades of body, two blues or grays, and two yellows, are usually all the variety needed in this work when a veneer is used. This very high fusing body has several advantages for this work over many of the *so-called* high fusing bodies found on the market.

"First—The body is of exactly the same material as the veneer, so that when completed the shell is of one grade of porcelain. The advantage of this is, that the union of veneer and body is more complete, although, the body having been once fused and refritted, fuses at a little lower temperature than it did the first time.

"Second—There is less shrinkage.

"Third—There is not the liability to cracking or checking upon cooling that there is when a lower grade of body is used in connection with the veneer.

"Fourth—No matter how many times the work may be fused, there is no danger of its becoming porous if it is kept absolutely clean, but a lower fusing body will frequently become porous when fused a number of times, due to the burning out of the flux which it contains.

"What is known as *low fusing* (gold matrix) porcelain has no place whatever in connection with this work. 'A' (Fig. 21) is a plaster model of a typical case of malformed enamel due to impaired nutrition from birth to about four years of age.

"Model 'A' was made in June, 1902, after which the irregularity of the teeth was corrected, and in July, 1903, the six anterior teeth were covered with porcelain by the process just described. 'B' is a model of the

case after it was completed. Age of patient at completion, nineteen years."

The Shell Crown with Porcelain Facing for Bicuspids, and the Use of Saddle-back, or Plain Rubber Teeth, in Connection with a Gold Barrel for Bicuspids and Molars.—In many instances of crown work for bicuspids, when the principle of retention of the shell or barrel crown is desired, the use therewith of a porcelain or detachable facing, in order to meet the esthetic requirements, is not only strongly indicated, but positively necessary.

Technique.—The method most commonly followed is that of constructing the band as previously discussed. When this has been satisfactorily formed the buccal portion of the band is sufficiently cut out to accommodate a cuspid facing selected to conform to the requirements of the case at hand. The model and articulation have been previously prepared. The facing is ground to fit the cervical and lateral portion of the band, made to conform to the articulation, also to the line of the adjacent teeth, beveled, and backed with a thin piece of 24-k. gold, 34 or 36 gauge may be used; the backing should completely cover the lingual surface of the facing, the gold burnished over all its edges, and trimmed smooth and even. The band is next detached from the model, the facing secured in proper position by means of wax; plaster and marble dust are mixed for an investment, just enough being used to cover the facing and hold it in its proper position; when the investment has hardened the wax is removed and the facing soldered in place. Many practitioners [1] recommend wrapping asbestos paper about the parts and securing this by means of binding wire, and then soldering the joint with 20-k.

[1] "Principles of Crown and Bridgework."

solder. This is a simple means of securing the facing in position, providing the facing is not moved in the act of adjusting the wire.

The band with the facing soldered to it is now returned to the model, the cusps accurately formed to the occlusion and the requirements of the band and facing, secured in position, invested, and soldered. Care should be exercised not to use too much of the investing material, otherwise considerable difficulty may arise in attaching the cusps to the band and facing; as previously suggested, just enough to cover the facing and sustain the cusps in position is all that is needed. Fig. 222 illustrates the different stages of construction.

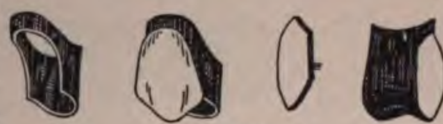


FIG. 222.

Another method of constructing the shell crown with porcelain facing, strongly advocated in many quarters, consists in first constructing the gold crown, using the swaged cusps. The root is dressed down to accommodate the facing, when it is placed in position upon the crown. The crown is placed in position upon the root and the area to be occupied by the facing is outlined upon the surface with an instrument. The part within the outline is cut out, and the edges made smooth with a file. A suitable cuspid facing is selected and accurately ground to fit the space prepared for it upon the crown. When ground as desired, sufficient allowance must be made for the backing by further grinding the band or facing. A backing of 24-k. gold, 34 or 36 gauge, is next fitted to the facing, the gold being allowed to project beyond the edges of the facing. In order to avoid overlapping of the gold in adapting it to the facing, it may be necessary to cut out a V-shaped piece at

both the cervical and occlusal ends. The facing and backing are replaced upon the crown, and with a sharp-pointed instrument the exact position of the facing is outlined upon the backing. The facing is now detached and the backing, secured in place with the self-closing pliers, is soldered to the crown, using a small amount of solder. The cusps may also be reinforced at this time. When this has been satisfactorily accomplished, the facing is placed in its proper position, all surplus material removed, and securely held in place by bending the pins, invested, as previously suggested, and soldered in position; or the asbestos paper may be wrapped about the crown in a way to fully protect the facing, and the soldering completed. Fig. 223 illustrates the different stages of construction.

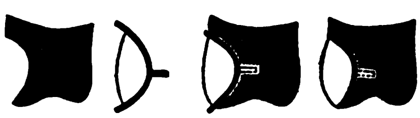


FIG. 223.

THE USE OF SADDLE-BACK TEETH.—In many instances superior esthetic results are possible in the use of saddle-back teeth, and where sufficient strength can be secured, especially in regard to the lingual cusps, very pleasing and permanent results are frequently obtained in their use.

Technique.—The band is constructed following the method pursued for a shell crown; next the bite and impression are taken, and the models adjusted to the articulator. A saddle-back tooth of suitable size and shade is selected. The band is detached from the model and cut out to admit adjusting the tooth. The latter is ground until it aligns with the adjoining teeth, properly occludes with the superior teeth, rests within the edges, and makes a close joint with the cervical portion of the band. When this has been satisfactorily established

the band and tooth may be set with zinc phosphate. A better plan, however, is to solder the tooth to the band; for this purpose the tooth, after being accurately ground to position and allowing for thickness of backing, is to have a piece of 24-k. gold, 34 to 36 gauge, perfectly adjusted to its lingual surface, after which the tooth is readjusted to the band and secured in place with wax. The tooth and band are invested, and, when the investment has set, the wax is removed from within the band, solder placed over the pins, and at two or three points to connect the tooth with the band, the heat applied until the case is completed. Fig. 224 illustrates the various steps in the construction of this crown.

Fig. 224.

THE BAND AND DOWEL CROWN

In constructing a crown for the anterior teeth it is quite obvious, as previously discussed, that the esthetic requirements demand preëminent consideration. In accordance with this, the porcelain crown is indicated in this part of the mouth. In many instances, for reasons previously stated, this form of crown may be adjusted without the necessity of modifying the imperative demand of the esthetic requirements, and the porcelain crown may be attached to the root without any display of gold. In the larger number of instances, however, the necessity for protecting the root is equally, if not more, impressive, in consequence of which a band is constructed, resulting in the so-called band and dowel crown. This is the form of crown under present consideration.

Technique.—The root having been prepared as pre-

viously described, a band is constructed from a piece of 22-k. gold, 29 or 30 gauge. If sufficient tooth structure has been allowed to project beyond the gum margin, not only is the proper trimming of the root for the reception of the band greatly facilitated, but the fitting of the band also, and the pain arising from forcing the sharp edge of the gold into the gum tissue is avoided. The use which many operators make of anesthetic solutions and cauterants to avoid the pain generally incident to the fitting of the band is to be deprecated. This mode of practice usually indicates carelessness in the preparation of the root, resulting in much irritation to the gum tissue from the sharp edge of the gold, which does not properly slide down upon the root. The band being adapted and the correct cervical curvature formed to conform to the lines of the gum tissue, it is trimmed down labially so as to allow the facing to approach the gum line as close as possible, and still meet the requirements for which the band is intended. Lingually the band is deeper. The band is now placed upon the root, and when in correct position only a line of gold should be labially visible. In many instances the band may be so far reduced in width as to make it invisible. The projecting tooth substance is now ground down to the edge of the band, and the band is curved out labially to permit of the correct apposition of the porcelain facing with the band (Fig. 225).[1] This may be done previous to grinding down the excessive tooth material. When the band is formed as indicated, a piece of 24-k. gold, 34 to 36 gauge, is attached to its upper sur-

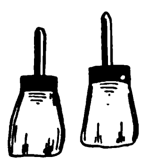


FIG. 225.

[1] The illustration is intended to show one crown with a faulty labial outline and the other with a correct labial curvature, but the illustration does not clearly emphasize the difference between the two crowns.

face to form the floor. This can be done readily by cutting a piece of metal largely in excess of the circumference of the band, placing the band upon it, and, at one point where the band meets the metal, borax and a minute particle of solder are placed. This is held over a Bunsen flame until the solder flows, and unites the band and plate at this point. The metal is now bent to meet the band at all points, and by means of borax, solder, and heat the union between the two is completed. The excess metal is cut down close to the joint, and this is made perfectly smooth with stones and disks. The cap may now be adjusted upon the root, and, if the adaptation is as desired, it may be set aside and the canal prepared for the dowel. For this purpose an iridio-platinum round wire of about 14 to 16 gauge for the superior anterior teeth is generally used, and about a 16-18 gauge for the inferior anterior teeth. The canal is prepared as discussed in the part dealing with its preparation. When the dowel has been adapted to the canal, the cap is placed in position and the slightly tapering end of the dowel is forced through the floor of the cap into the canal. In many instances the dowel and cap can be withdrawn in correct position without the assistance of an impression, but it is safer to take an impression in wax, into which a combination of about 1/3 plaster and 2/3 marble dust is poured and set aside to harden. When this has occurred a low degree of heat is sufficient to separate the wax; borax is placed around the dowel at the perforation of the floor of the cap, and with a small particle of solder the dowel is fastened to the floor of the cap. The investment is now removed, and the cap and dowel placed in the acid solution to be cleaned, after which it is replaced upon the root and the bite and impression secured. Prior to pouring the model it is well

to give the dowel and the interior of the cap a coating of melted wax. This admits of its easy removal from the model, which act becomes necessary, prior to investing the waxed facing, cap, and dowel, that the facing may be soldered to the cap. Many operators, in order to avoid removing the crown from the model, prior to investing it, also the risk of displacing the facing attendant upon its removal, no matter how slight the risk may be, prefer to pour the model from a combination of about equal parts of plaster and marble dust. When set this combination is sufficiently resistant for light handling, and when the facing has been adapted to the cap and waxed in position it can be invested by covering the porcelain with the same combination as was originally used to make the model, without removing the cap and facing from the model.

The model and bite are adjusted to the articulator and a suitable facing selected. This is ground to meet the indications, especially in its relation with the cap, with which it should form a perfect joint. It may be necessary to cut away the projecting end of the dowel in order to provide space for the proper adjustment of the facing. In this relation it is always well to bear in mind that, if the dowel is cut too close to the floor of the cap, and if this has been formed of too light a gauge of metal, it may prove to be unequal to the strain imposed upon it in mastication, and the cap may be torn from the dowel. When the proper adjustment of the facing has been secured, its inner surface should be ground down to make space for the backing, *and the incisal edge should be beveled toward the pins* in order that a sharp angle may exist, instead of the rounded edge of the facing; the beveled edge admits of a closer adaptation of the backing, and

when the soldering is completed results in a degree of protection to the facing which is absent when the bevel is not made.

The backing is made from a piece of 24-k. gold, 34 to 36 gauge, the entire lingual surface of the facing being covered. Dr. Goslee[1] claims that the protection which the backing gives the facing can be increased, in the use of a second piece of gold, preferably 22-k., 29 or 30 gauge. This second piece of gold is fitted over the first piece, which has been closely adapted to the facing with a surplus extending over the incisal edge. The second piece of gold extends from the pins to the incisal edge with a corresponding surplus extending beyond this edge. When adapted the two backings are removed from the facing and carefully soldered together. When this has been satisfactorily accomplished, the backing is cleaned in the acid solution, placed in position upon the facing, and thus retained by bending the pins down upon the backing until they touch it. In bending the pins, the ends only should be caught in narrow flat-beaked pliers to relieve the strain upon the metal next to the porcelain. If this is not done the porcelain may be fractured. Many crown and bridge workers claim that in bending the pins upon the backing a slight fracture of the porcelain around the pins inevitably follows the soldering process. In place of bending the pins, a sharp instrument is used to shave a thin section of the metal of the pin, and this securely holds the backing in place without the risk of fracturing the porcelain. The gold is now finished to close contact with the edges of the facing. All overhanging gold should be removed, otherwise the porcelain will fracture along the edge, due to its expansion in heating up for soldering, and

[1] "Principles of Crown and Bridgework."

the restricting effect upon the expansion of the turned-over edge of metal.

As much of the appearance of the finished crown depends upon the success of the joint between the facing and cap, Dr. Goslee[1] recommends grinding away the backing at this edge, so that the porcelain facing may be placed in direct contact with the cap. In this manner Dr. Goslee[2] claims the porcelain may be brought into closer proximity with the gum, also securing a more perfect joint than if the backing extends to the edge of the cap, and does away with the uncertainty of uniting the two in the labial region with solder. In the writers' experience the joint can be *perfectly* filled with solder, if prior to investing the facing it is removed from the model, and a thin mix of borax painted in this region, both over the backing and the cap. This prevents the investment material from running into the joint, which is the cause of the imperfection to be seen in many cases.

The facing is now replaced in position and waxed to the cap; both are removed from the model, the space between the backing and cap filled with wax up to the porcelain edges. This keeps the metal free of investment material, and, as previously noted, the presence of the investment material upon the metal interferes with the proper flow of the solder.

The crown is now invested and completely covered to the wax. Care should be taken to fill the interior of the cap, otherwise the floor of the cap might be fused in the soldering process. When the investment has hardened, the wax is removed and the case soldered and finished in the usual manner.

The Use of Partial or Half Bands.—The partial band

[1] "Principles of Crown and Bridgework."
[2] *Ibid.*

is indicated in those cases where for apparent reasons the presence of the metal upon the root would be likely to lead to pathological conditions ending in loss of the root, as, for example, in individuals with decided pyorrhetic predisposition, and where the root to be crowned already manifested the effects of this disease. The partial band might also be preferred for esthetic reasons, especially if subsequent recession of the gum is likely to take place, bringing the gold band prominently to view. Many operators prefer the partial band in all cases where a strong healthy root is to be crowned, claiming that in its use sufficient protection is afforded the root to prevent fracture, while the esthetic as well as hygienic effect is increased.

Technique.—The partial band may be constructed by first forming a full band, after the plan previously outlined. When the band has been properly adjusted and trimmed, the floor is prepared by attaching a piece of pure gold 34 to 36 gauge to the lingual portion of the band. Precautions must be taken not to solder the floor to the labial portion of the band. This can be done by coating the interior of the band in the region not to be soldered with a solution of whiting, or by bending the plate away from the labial portion of the band. The surplus metal should be cut away even with the band, and the labial portion of the latter should be cut out as desired. The cut band and floor is now adjusted to the root, and the projecting portion of the floor perfectly adapted to the labial portion of the root. The cut ends of the band should also be closely adapted to the root. The subsequent stages are similar to those outlined for the construction of the band and dowel crown.

Another method of constructing the partial band is as follows: A piece of 24-k. gold, 34 to 36 gauge, or

platinum may be used, is cut, so that it not only covers the face of the root, but extends far enough beyond the lingual margin, that the projecting portion may be turned and burnished against the lingual portion of the root which projects beyond the gum tissue. By giving the metal to be adapted to the root an egg shape, it has been claimed that it is cut in the best possible form for the formation of the half band. To facilitate the adaptation of the gold against the lingual portion of the root, it should be cut at two points (Fig. 226). When this is done the bent portion of the metal may be perfectly adapted against the projecting tooth structure into the form of the partial band. The band is to be subsequently strengthened by flowing solder over it, care being taken to paint the inner portion of the band with a solution of whiting, to prevent the solder from flowing to the inner surface of the band. The subsequent stages are similar to those previously discussed.

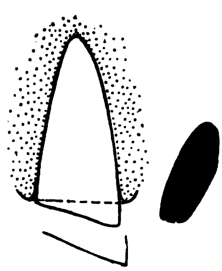


FIG. 226.

The Use of Detachable Facings.—The difficulties under which broken facings are repaired, after the crown has been permanently mounted, led to the introduction of the detachable facing, in the use of which the former difficulties are considerably lessened. The advocates of this form of facing make many claims for its use, only some of which are allowable. The chief claim in its favor lies in the simplicity of replacing a broken facing. The metal support remaining in position, a facing similar to the one broken is selected, and with little grinding is fitted into position and cemented. The shade and translucent effect may be exactly reproduced. This cannot be done with a soldered facing. The shade of the first fac-

ing is rarely duplicated, and the translucent or life-like effect is invariably destroyed in a soldered facing. The claim that the cemented facing is less likely to fracture, which claim is allowed by some writers,[1] is not concurred in by the authors. A cemented facing is held rigidly; there is no give to a facing so held in position when stress is applied, but even if this were allowable (which is the condition if gutta percha is used as the setting medium) the fact that the detachable facing presents less bulk of porcelain, and that the backing is not as protective as the perfectly adapted and soldered backing, in the writers' judgment, make the detachable facings appear weaker, and experience apparently sustains this view. The following detachable facings are procurable at the depots: *the Mason, the Roach, the Dwight,* and *the Steel,* named in nearly every instance after the men who designed them, the chief difference between them being in the form of attachment between backing and facing.

Technique.—The cap is constructed as previously outlined, the models secured and mounted upon an articulator. A suitable facing with its backing is selected and ground to fit the cap and meet the usual indications. When this has been satisfactorily accomplished, the backing and facing are waxed in position and the facing removed. Subsequently the backing is soldered in position, and when trimmed and finished the facing is adjusted. This is the method pursued in adjusting the Mason facing (Fig. 227). The other forms differ only in the method of securing the attachment of the

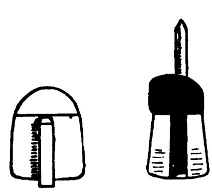


Fig. 227.

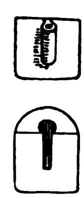


Fig. 228.

[1] "Principles of Crown and Bridgework."

facing. From present indications it does not appear as though the profession utilized these facings to any great extent. The Steel facing is now designed with a slot in the porcelain which takes the place of the platinum "rib" originally used. As constructed at the present time this facing enjoys a wider popularity with many workers, and has taken the place of many of the interchangeable facings introduced from time to time.

Repairing Broken Facings.—As previously stated, the difficulty of repairing broken facings led to the introduction of the detachable form of facing, and, while these may subserve a useful purpose in admitting of an easy method of repair, the repaired detachable facing is not stronger than, if as strong as, the soldered. On the other hand, the risk involved in removing a band and dowel crown that a new facing may be soldered to it is so great that many operators prefer to adjust a new facing to avoid removing the cemented dowel and band.

Technique.—The method usually followed is to grind down the pins projecting from the backing until a perfectly smooth surface is formed. A suitable facing is selected, and two holes drilled through the backing for the reception of the pins. The facing is then ground to conform to the requirements of the case. The backing and tooth may now be roughened, the facing set with cement, and the pins bent over upon the backing. If, in grinding the facing to position, it is found that the pins do not project far enough beyond the backing to admit of their being bent over upon the backing, the lingual portion of the backing must be reduced by means of stones until the desired extension of the pins is secured. Subsequently the pins may be dressed down somewhat for the greater convenience of the patient.

Another method consists in grinding down the pins

on the backing until a smooth surface is secured. A slot is then cut into the backing, perforating it the distance of the two pins (Fig. 229). A suitable facing is selected, the pins bent over to meet and form the arc of a circle; asbestos paper is wrapped around the facing, and the joint formed by the two pins is then soldered. The facing, with the pins bent and soldered to form the arc of a circle, is placed in position, the pins extending through the slot previously cut in the backing, and ground to meet the requirements. A slot or groove running in the direction of the long axis of the root is next cut into the lingual surface of the backing, extending from 1/8 to 1/16 of an inch above and below the transverse slot. The slot for the reception of the pin may be cut into the labial portion of the backing. This increases the difficulty of adjusting the facing without adequate compensation. The groove is formed for the reception of an iridio-platinum wire of about 18 gauge, and is cut deep enough into the backing so that when the wire is placed within, it should form a smooth surface with the lingual portion of the backing (Fig. 230). The facing is now placed in position, the wire inserted to hold it in position by fitting into the opening formed by the pins, and if all the relations are satisfactory the facing and wire are removed, dried, and set with cement. This method of repair will prove very satisfactory in most instances.

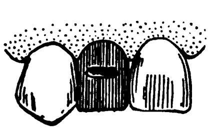


FIG. 229.

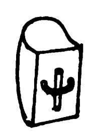


FIG. 230.

Another excellent plan of repairing a crown the facing of which is fractured is that suggested by Dr. C. J. Underwood of Elgin, Illinois. A similar method has also been practiced by Dr. Wm. Mitchell of London, Eng-

land, and is now spoken of as *Underwood's and Mitchell's Method.*[1] The method consists of grinding down the pins on the backing, and by means of a crosscut fissure bur cutting slots into the backing as shown in Fig. 231. The facing is then ground according to the indications and fitted with a backing made of 34 gauge pure gold. After being closely adapted and trimmed, the backing is drawn away from the facing in the cervical region sufficiently far so that, when the facing is slid into position, its backing will pass beneath the old backing. If it is found, when the facing is in position, that its pins do not extend beyond the new backing, the lingual portion of the old backing must be ground

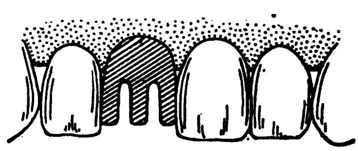


FIG. 231.

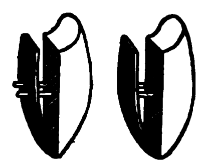


FIG. 232.

down until this is accomplished. The new backing is now closely adapted to the lingual portion of the old, the parts securely maintained in their proper relation by means of wax, the facing and backing carefully removed, invested, and soldered to the pins at the proper position. The backing is also to be sufficiently strengthened by flowing solder over it. The case is then finished in the usual manner and cemented into position (Fig. 232).

The method evolved by Dr. Emory A. Bryant, of Washington, D. C., is a very effectively devised procedure for securely attaching a new facing in position. The plan is especially indicated in replacing bicuspid and molar facings, as the thickness of the backing in

[1] "Principles of Crown and Bridgework."

these locations affords greater security to the attachment than in the anterior portion of the mouth; however, here it may also be applied.

Dr. Bryant countersinks the old backing from the lingual surface, after the facing has been selected, and ground to position, and the old backing perforated for the reception of the pins of the new facing. After countersinking these perforations, as previously stated, with the countersinking reamer, until a corresponding countersunk nut can be adjusted flush with the labial or buccal surface of the old backing, the pins of the facing are threaded by means of a screw plate. The gold nuts are tapped to fit the thread of the pins. The backing is covered with cement. the facing placed in

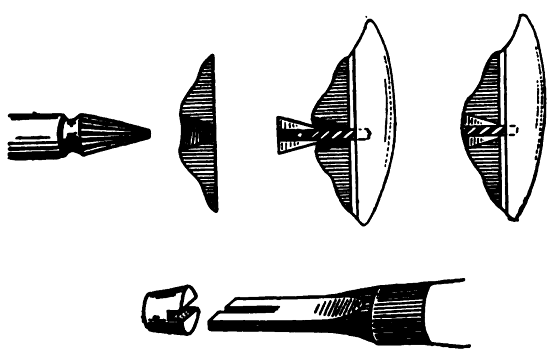


FIG. 233.

position, and the nuts cautiously but firmly tightened to place. Subsequently any projection upon the lingual surface is ground away. Fig. 233 illustrates this method.

Other methods for replacing broken facings have been introduced, some of which are unnecessarily complicated. Those above described will best meet the usual requirements.

The Band and Dowel Crown for Bicuspids and Molars.—As has been stated in discussing the shell crown with the porcelain facing, the necessity for meeting the esthetic demands is almost as urgent in the case of the bicuspids as it is in the anterior portion of the mouth. The exceptions to this have been noted, but the rule of practice should be to exclude the conspicuous display of gold from the bicuspids, and in many instances from the molars as well.

If after careful consideration it is concluded that the band attachment alone is not sufficiently secure, the band and dowel crown must be constructed. This may be accomplished in two different ways, with the use of the ordinary cross-pin facing, and with the saddle-back tooth. The use of the facing is not as esthetic a reproduction of the bicuspid crown as may be attained in the use of the saddle-back tooth, as with the former the occlusal surface is reproduced in gold, while with the latter this is avoided; but the former method is usually regarded as possessing greater strength.

Band and Dowel Crown with Facing.—The cap is prepared after the method discussed in its construction for the anterior teeth, and the dowel fitted in the canal and soldered to the cap. If two dowels are employed, which is rarely indicated, if the cap is properly adjusted, the precaution must be taken to have them project beyond the floor of the cap in a way that does not interfere with the proper fitting of the facing. It may be necessary to cut away the projecting dowels; when this is necessary, they should not be cut too close to the floor of the cap, for reasons previously indicated (see band and dowel crown for anterior teeth). The bite and impression are next taken, and the prepared mod-

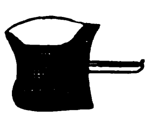


Fig. 234.

els mounted upon the articulator. A suitable facing is selected, ground to form the proper adaptation with the cap, reduced along the occlusal end to make room for the gold cusps, and then beveled. Next it is backed with a piece of pure gold 34 to 36 gauge, which is closely adapted to all the edges, except in the occlusal region, where it is allowed to project beyond the edge. The facing is now placed in its proper relation to the cap, and retained in this position by means of wax. The gold cusps are next produced, after any of the methods described in treating of the shell gold crown. When these are formed, the gold is cut away in the buccal region, which allows the gold cusps to be adapted to the facing in a way that materially reduces the thickness of the gold along the occlusal edge, and still provides adequate protection to the facing. The cusps are waxed when in proper position with regard to the facing, and when all the parts are properly related, the next step in the procedure is to remove the facing and cusps, care being taken not to displace them in any way, invest, solder the two together, and fill the lingual portion of the cusps. The facing, with the cusps now attached to it, is again placed in position, and built out with wax to restore the approximal contact. A piece of 24-k. gold, 36 gauge, extending from cusps to cap, is now burnished over the wax on each approximal side. This greatly aids in giving the wall of contour during the subsequent soldering. The crown is finished in the usual manner.

Band and Dowel Crown with Saddle-back Teeth.—The cap and dowel are prepared, the bite and impression secured, and the models mounted upon the articulator, as previously indicated. A suitable tooth is selected and ground to form a perfect joint with the cap, and to restore the contact and occlusion. When this

has been accomplished the tooth is backed with a piece of 24-k. gold, 34 to 36 gauge. This is trimmed to the edges of the tooth and securely held in place as previously indicated. It is replaced in its proper position, held in place by means of wax, invested, soldered, and finished in the usual manner. A vulcanite tooth may be used in place of the saddle-back tooth, and as it is made up of a greater bulk of porcelain in the lingual portion than the saddle-back tooth, may be regarded as being stronger. When this form of tooth is used the heads of the pins must be ground away, or cut off, in order that the backing may be properly adjusted; the lingual surface of the tooth should also be ground smooth, otherwise the procedure is similar to that followed in constructing the crown with the saddle-back tooth.

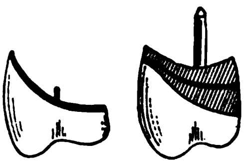


Fig. 235.

THE PLATE AND DOWEL CROWN

As indicated in discussing the band and dowel crown, cases may present at times where the use of a band is contraindicated. This might occur in relation to roots with evident pathological predisposition, where the preparation made necessary by the contemplated adjustment of a band would be likely to excite a pathological state; or where the presence of the band impinging upon the pericementum would tend to provoke a condition of disease. Similarly a contraindication to the use of a band may be found in a condition of marked recession of the gum, in which cases too deep a band would be necessary, and which is to be excluded for esthetic considerations. Some writers[1] state that the use of the band may be excluded in those cases were "the root is sufficiently large

[1] "Principles of Crown and Bridgework."

and strong, and free from the evidencies of caries or disintegration, as to probably require no support and protection, such as the application of a band affords." If no condition exists to contraindicate the use of the band, as indicated above, the fact of "the root being large and strong," which, of course, may be sufficient to overcome fracture, but which is not sufficient to overcome the factors of decay, is in itself, when related to the question of caries, not convincing as a reason for the exclusion of a band. In fact, it appears that just in these cases, providing no condition exists which definitely excludes the use of a band, the protection against caries afforded by a properly adjusted band is very desirable. According to the writers' experience, no matter how carefully the plate is adapted to the base of the root, in many cases, sooner or later, evidences of disintegration can be noted. This usually occurs in individuals with a decided susceptibility to caries. Therefore, in these cases, irrespective of whether the root is large and strong or not, the rule of practice should be to protect the root from caries by the use of a band, providing no stronger reason is to be found to exclude its use.

Technique.—The first step is the preparation of the root, which differs from the preparation adopted for the crown with a band, in that it is not necessary to cut down its periphery in order to properly adjust the band, but an important feature of its preparation is based upon its resistance to the stress acting upon it, and is secured in giving the base of the root the form as indicated in Fig. 236. The plate which rests against the root, and which forms the base of the crown, assumes the form indicated in Fig. 237, and when properly adapted to the root securely guards against movement of the crown through the action of the forces directed

against it. The labial slope is carried slightly beneath the gum margin for the advancement of the esthetic

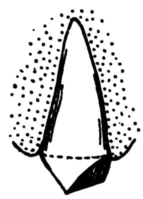


FIG. 236.

FIG. 237.

result. The lingual slope is formed so that the root is left slightly projecting beyond the gum line. This places the joint in a region where the accuracy of the adaptation of the plate can be better noted, and also where the washings of the saliva, the movements of the brush and tongue are more likely to prevent disintegration of the root. In adapting the plate and dowel crown to the first bicuspid a similar preparation of root is advisable; for the second bicuspid, where the line of the applied stress is mainly in the vertical direction, the flat base is sufficient to overcome any tendency toward displacement. When the root has been properly formed a piece of 24-k. gold, 34 to 36 gauge, is accurately adapted to the root end. In most instances this can be satisfactorily accomplished by burnishing with hand instruments. If this means fails to secure the desired accuracy of adaptation, a fusible die and counterdie may be formed, and the plate swaged. The plate being adapted as desired, the root canal is prepared, and for the central incisors and cuspids a 14 gauge iridio-platinum dowel is fitted in the prepared canal. The plate is now placed in position, and the dowel made to perforate it by being forced into the canal. Frequently the dowel and plate can be withdrawn, perfectly related, without the aid of an impression. When this can be done, the relation between the two is permanently secured with a minute particle of 20-k. solder; otherwise an impression must be taken, and a model prepared after which the soldering is done. The plate and post

are replaced in position to determine the fit; if this is satisfactory, it is well before proceeding to reinforce the plate by flowing 20-k. solder over its surface. Unless this is done, subsequent handling may destroy its perfect adaptation to the root. The bite and impression are next secured, and the models mounted upon the articulator. A suitable facing is selected, and ground to meet the requirements. It is then backed with 24-k. gold, 34 to 36 gauge, as previously indicated, invested, soldered, and completed in the usual manner. Fig. 238 illustrates the steps in the construction of this form of crown.

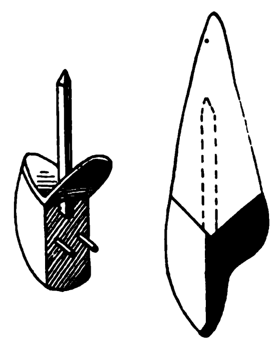


FIG. 238.

THE CASTING PROCESS IN RELATION TO CROWN-WORK

Attention has been directed to the casting process in considering the different ways of constructing the gold shell crown. It was then stated "that before long (the casting method) will be generally recognized as being the most accurate method, as well as affording the most artistic effects for reproducing the forms of crowns." In a paper on "The Application of the Casting Process to Crown and Bridgework," by Dr. Hart J. Goslee, printed in the *Western Dental Journal* for April, 1911, he writes as follows: "The advent of this process has completely revolutionized all of our former methods; has made it possible to eliminate, or at least greatly diminish, all of the deficiencies mentioned; has relegated a multitude of useless, impracticable, empirical methods to the memory of the past; has made it possible to fol-

low a more or less scientific and systematic line of procedure, and to accomplish the combined requirements of *adaptation, strength and cosmetics* to the very highest degree, in a manner heretofore impossible." The deficiencies of the "facing" have been apparent, almost since their introduction, to many crown and bridge workers, for which reason many gave preference to the all porcelain crown, such as the Logan, and the improved type of all porcelain crown later introduced with a detachable dowel, such as the Davis, Justi, S. S. White, and others. While the detachable pin all porcelain crown presented great advantages over the type of porcelain crown with the permanently attached dowel, an element of weakness still existed in the unprotected root end. This, however, was quickly and effectively overcome in the use of a band, and the detachable all porcelain crown with the band attachment stands today as a very high achievement in crown work. The casting method has simplified the technique of constructing the base, and added to its permanency and artistic effect, so that at the present time the very highest form of crown work for the ten anterior teeth is to be found in the use of an all porcelain interchangeable crown, as the Davis, etc., with the utilization of the casting process for the construction of the base, modified as this may become in the future for the protection of the root. For convenience we will here consider the casting process in relation to the band and dowel crown, and to the plate and dowel crown, reserving its consideration in relation to the all porcelain detachable crown, when we later on discuss this type of crown.

Casting Method in Relation to the Band and Dowel Crown.—The root is prepared, as previously indicated, with a stronger tendency to shorten it lingually, to place

the band as much as possible from view. The band is then fitted, from a piece of 22-k. gold, 30 gauge, and trimmed to an exact adaptation to the lines of the root. The dowel is fitted in the previously prepared canal, and the crown is ground to position. Where the base of the crown has a greater area than the end of the root, which will frequently be found to be the relation with the present supply of crowns found at the depots, it should be ground down to the size of the root. When these indications have been met, the crown is oiled to prevent the molding wax from adhering to its surface; the band and dowel are placed in position upon the root, the softened wax adapted to the crown, the two forced into place and the wax chilled and molded as desired. If it appears desirable to reinforce the band, the wax can be carved, so that a thin layer extends upon the surface of the band. The porcelain crown and cap may now easily be detached, and by securing the end of the protruding dowel with pliers the crown can readily be separated from the wax. When all the parts are in exact relation, the wax may again be carved to any desired form according to the judgment of the operator. Before inserting the sprue wire, it should be seen that the band is securely held in place, otherwise just at the moment of investing it may slip from its position, and occasion unnecessary delay and work. The sprue wire being in position, the porcelain crown is removed, and the wax model with the band and dowel in position is now ready for the investment (Fig. 239).

In place of the porcelain crown, if the use of the ordinary facing should be desired, the casting method may be as effectively utilized here as under the previous conditions. The casting may be made against a piece of 34 to 36 gauge crown metal, which previously has

been made into a backing for the facing, and removed with the wax mold for investment, or it may be made by adopting the wax directly against the facing, after the facing has been adapted to the root, and then subsequently removing the facing, inserting carbon points into the openings in the wax made by the pins of the facing, investing and casting. The two pin holes in the casting are enlarged and the facing subsequently cemented in position. This is similar to the preceding method, except that in the use of the backing a smoother adaptation of the gold to the facing is secured.

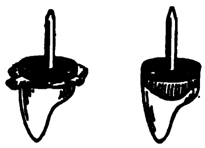


FIG. 239.

Another method is to make the casting directly against the porcelain facing. Good results have been obtained by the use of this method, although the risk of casting molten gold directly against the facing is considerable, and furthermore, in case of subsequent fracture, the facing can only be replaced by one of the methods followed for the repair of broken facings. In view of these disadvantages, which are considerable, it appears to be a better plan to make the casting, reproducing the pin holes, as previously indicated, and then cementing the facing to position.

The method is as follows: The root is prepared as previously indicated, and if a band is to be used it is adapted to the root. The canal is next prepared for the dowel; when the dowel has been fitted to the canal, molding wax is softened and adapted to the end of the root; the facing, which previously has been ground to meet the requirements and backed with platinized gold, 34 to 36 gauge, is now forced into its proper position, the wax chilled, and the facing, wax, and dowel removed; if a band has been used it is removed from the root (it

is rarely withdrawn within the wax), and placed in its position in the wax. The wax is carved to the desired form, and, if any doubt exists as to the correctness of the adaptation of the different parts, the facing is to be replaced in position. Being assured of the desired relation, the facing is very carefully removed from the backing by forcing the blade of a knife between the facing and backing. The pin openings through the backing and into the wax are filled with carbon points. When this is done the case is ready for investment (Fig. 240).

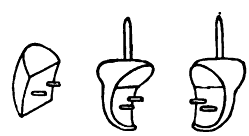


FIG. 240.

DOWEL CROWNS WITHOUT PLATE OR BAND

The so-called all porcelain crowns have had an extensive use in the past, principally because of the greater ease in adapting them, and the better esthetic effect obtained in their high translucent appearance. On the other hand, very important objections may be urged against them. It is extremely difficult to secure a crown which will correspond in size to the base of the root, and furthermore, after the crown is adapted and mounted, the unprotected state of the end of the root is not unlikely to result in fracture, or more or less disintegration. These objections may be completely overcome in the use of a band, or partial band, constructed after the method discussed in relation to the dowel crown with band; or in utilizing the casting process as a means of accomplishing a similar purpose. In some isolated cases, as, for example, in cases of marked recession of the gum, or in those instances with evident pathological predisposition of the root, where the presence of a band is contraindicated, or in those instances where time is an exceptionally important factor, the all porcelain crown

still occupies a position of usefulness in relation to the anterior teeth. The all porcelain crown may be classified under two heads, as previously stated, according as to whether the dowel is *detachable* or *non-detachable.* As an example of the detachable porcelain crown we have the Davis, Justi, S. S. White. For the second variety we have the well known Logan and Brewster crowns. Other makes may be found upon the market, both in the *detachable* and *non-detachable* forms, but as the distinguishing differences between all those belonging to the first class and all those of the second class are to be found in unimportant details, it will not be necessary here to discuss each form found upon the market. While both classes of crowns are still extensively used, the detachable form of crown possesses advantages which almost from the very beginning of its introduction bespoke for it a most cordial welcome. The present tendency is to give the detachable form of crown preference over the non-detachable form.

Detachable Crowns.—THE DAVIS CROWN.—The Davis crown was not the first crown introduced where the dowel was adjusted independent of the crown. The Foster and Gates-Bonwill crown had been in use many years before the appearance of the former crown, but owing to the marked liability to fracture which characterized the earlier forms of porcelain crown it never attained extensive use. In the Davis crown this deficiency is almost entirely overcome. Sufficient bulk of porcelain is here found necessary for strength, but in providing the bulk of porcelain the basal area of the crown, in most instances, exceeds that of the root, necessitating considerable removal of porcelain to reduce the size of the crown to that of the end of the root.

The dowels which are furnished by the supply house

for the Davis crown are of two sizes. In most cases the smaller size may be utilized, and is to be recommended, as the extensive drilling of the canal weakens the root and is more likely to invite its fracture. A twist drill to correspond to either size dowel may be secured from the supply house that furnishes the crown and dowel, and through its use the canal may be reamed out so that the dowel can be perfectly adjusted to it.

In preparing the root, if the crown is to be adjusted without a band, no peripheral trimming is necessary. The labial aspect of the root is ground to a line beneath the gum margin, for the esthetic effect; lingually the root is allowed to project somewhat beyond the gum line, as illustrated in Fig. 241. A suitable crown being selected, it is as perfectly adjusted to the end of the root as the conditions will allow. The canal is next prepared for the reception of the dowel. If the drill above referred to is used, but little difficulty will be encountered in securing a perfect adjustment of dowel to canal. In some cases the full length dowel, as supplied by the dental depot, will have to be shortened to be properly adjusted. When the dowel has been fitted to the canal it may be placed in its proper position in the crown, and secured with wax. The dowel and crown are now adjusted to the root, and when a satisfactory adjustment has been attained the dowel and crown are permanently mounted.

Fig. 241.

Davis Crown with Cap Attachment.—Reference has previously been made to the advisability of protecting the end of the root, in almost all cases where the Davis, or similar crown, is to be adjusted, by means of a band and cap attachment. The application of this or similar crown so combined marks a distinct advance in crown

work. At the present time the technique for constructing the cap is considerably simplified by means of the casting process, through which better adaptation, greater strength, and a higher artistic effect are secured. This has been previously discussed. If, however, it should be desired to construct the band and cap without the aid of the casting process, the following plan may be adopted: The root is prepared as indicated in considering the band and dowel crown. A piece of 22-k. gold, 29 or 30 gauge, is made to conform to the end of the root, and the two ends soldered. The band and projecting root end are now ground down to conform to the requirements. A suitable crown is selected and ground to conform to the root, not only to the base of the root, but as the area of the crown is quite likely to be greater than that of the base of the root, the crown should be reduced in size to correspond to the outline of the root. The canal is next prepared for the dowel, which is fastened with wax to the crown, and adjusted to the canal so that the crown can be placed in its proper position. A piece of 24-k. gold, of about 34 gauge, is next perforated for the dowel, and cut to allow for an overlap of about 1/32 of an inch over the band. When this piece of gold plate is in its position upon the crown, the crown is placed in its proper relation to the root, and the gold plate burnished into close adaptation with the band. When this has been satisfactorily accomplished the crown is removed, the gold plate and band placed in accurate relation with each other, and soldered together to form a cap. The cap, when formed, is adjusted to the root, the soldered portion is ground down to form a smooth surface. The crown with the dowel waxed to it is now adjusted to the root and sustained in its relation to the cap with wax. The crown and cap are next

carefully removed from the root, investment material is poured in the interior of the cap to sustain the dowel in its proper position, and when this has hardened the crown is loosened from the dowel by softening the wax which held crown and dowel together; the dowel is then soldered to the cap. When this has been accomplished the cap is polished and cemented in place in the usual manner. This method of forming the cap has been suggested by Dr. Goslee, and, while the usual method of forming it may be followed, we believe this to be preferable. After the cap has been set the crown is placed in position, and if properly related may also be set. In case of subsequent fracture of the porcelain crown a second crown may readily be adapted to the cap.

The Davis crown may also be used as an all porcelain crown, after the following plan: The root is prepared as indicated for the reception of a band. Platinum plate of about 29 gauge is cut a trifle longer than the measurement of the root, in order that an overlapped joint may be formed. This is necessary for strength. The ordinary soldered end to end joint would be opened in the fusing of the porcelain, which is a procedure in this form of construction. The band being overlapped, it is soldered with pure gold or 25 per cent. platinum solder. The band is now trimmed to the requirements and made as narrow as possible. A piece of 32 gauge platinum is made to conform to the band and permanently attached to it with platinum solder. When the joint has been trimmed down smooth and even, iridio-platinum wire of suitable gauge and length is fitted into the canal for the dowel, and later soldered to the cap. With the cap and dowel in position, an impression is taken; a bite, if necessary, is also secured. A thin layer of melted wax is placed within the band and upon the

surface of the dowel to admit of its easy removal from and replacement upon the model. A suitable crown is selected and ground to meet the requirements. Special emphasis is here laid upon the necessity of grinding the approximal sides of the crown so that it will overlap the band labially and lingually, and thus come closer to the margin of the gum, and also hold the porcelain which is added to cover the band. The approximal sides may be further ground away to admit of a second application of body to completely fill the space between the cap and crown. The interior of the crown is next filled with body and the crown forced to place. By gently tapping the body is well adapted around the dowel. The baking is done in the usual manner. Fig. 242 illustrates this crown.

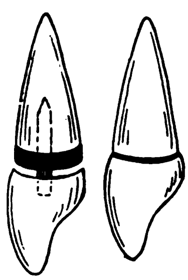


Fig. 242.

Non-Detachable Crowns.—The Logan Crown.—The Logan crown is representative of the porcelain crown with non-detachable dowel, and, while its use has greatly diminished ever since the introduction of the Davis crown a brief consideration of the methods of its application to the roots of teeth may not be out of place. The introduction of the Logan crown marked a distinct advance in crown work, principally because it was made with a depression surrounding the dowel which enabled the operator to adapt it to the root without weakening the dowel. It attained a high state of popularity, also because of the variety of molds and shades which were placed upon the market, enabling one to secure a splendid esthetic effect in almost all instances. The flattened platinum dowel is baked in the crown with its greatest diameter in a labio-lingual direction, in accordance with the principle that, as the application of stress is in this

direction, the greatest diameter should also be in a similar direction, to secure the greatest resistance. Furthermore, it was also claimed that, in the preparation of the canal for the reception of the dowel, the root was left in the strongest form to resist fracture. But the excessive removal of the root substance in the labiolingual direction to accommodate the flattened dowel leaves it decidedly weakened, and the fracture of the root is not an uncommon occurrence following the use of a Logan crown.

The root is prepared as indicated for the Davis crown. A suitable crown is selected and ground to an accurate adaptation to the root. This is most conveniently secured in the use of articulating paper. In the *Cosmos* for June, 1894, Dr. Kirk describes the following method: "Cut several small pieces, about one-quarter inch square, from a strip of thin articulating paper. In the center of each punch a hole with the cofferdam punch, about the size of the largest hole made by the Ainsworth punch. Having prepared the root end, slip the perforated piece of articulating paper over the pin of the Logan crown and press it firmly into position in contact with the root. Upon withdrawing the crown and removing the articulating paper, the points of contact will be found to be marked black. Grind these off carefully, readjust on the root as before, grind again, and continue the operation of fitting and grinding until the mark made by the articulating paper on the contact surface of the crown presents as a uniformly unbroken black ring. When this has been accomplished the crown will be found to fit the root end with the utmost accuracy" (Fig. 243).

Logan Crown with Cap Attachment.—To secure the advantages considered in relation to the application of

the cap attachment for the Davis crown, a similar form may be adopted for the Logan crown, and when so constructed far exceeds in permanency the ordinary crown.

FIG. 243.

The root is prepared according to the requirements indicated for the adjustment of a cap; when this has been constructed and trimmed in the usual manner, the crown which has been previously selected, suitable for the case, is adapted directly to the root. This adaptation is made only to the labial portion of the root. The lingual and approximal portions of the crown are ground away to form a V-shaped space, large enough to be subsequently filled with solder. The cap may now be placed in position, perforated to receive the dowel, and the adjustment between crown and cap improved, if this should be necessary. The crown being adapted as desired, and the V-shaped space large enough, as previously noted, the crown is removed, and a piece of 36 platinum plate, large enough to cover the base of the crown, is perforated by the dowel and closely adapted to the edges of the crown. In trimming the platinum to the outlines of the base of the crown, Dr. Goslee recommends a slight *lingual* extension of the plate, which, in the subsequent act of investing, is caught in the investment material, and prevents the platinum from being pulled away from the crown, owing to the contraction of the solder, and the formation of a space between the

metal and the base of crown. The cap being in position upon the root, a piece of softened wax is placed over the platinum on the base of the crown, and the crown forced into position. When accurately apposed with the cap the wax is chilled, and by gently pressing upon the edge of the band with a hoe excavator the crown and band are detached from the root. The crown with the cap and dowel in position is now invested, and subsequently

FIG. 244.

FIG. 245.

the wax removed from the V-shaped space, and solder flowed in to permanently unite crown and cap.

The Logan Crown with Platinum Cap or Plate and Porcelain.—This is similar to that employed in relation to the Davis crown when porcelain is added to secure crown to cap for a better esthetic result, excepting that the dowel is not changed, and that the relation between crown and cap or plate is first secured by soldering before the porcelain is added. The preliminary work of root preparation, fitting of cap or plate to the root, the selection and grinding of the crown, is followed here upon the same lines as previously discussed. When the relation between crown and cap has been accurately formed the relation is to be permanently sustained by soldering the dowel to the cap or plate with pure gold. This prevents subsequent distortion through contraction of the porcelain. Later porcelain is added to fill in the

space between the crown and plate. Fig. 245 illustrates the crown with both the cap and plate form of attachment.

METHODS OF RETENTION

Crowns are retained in position by the use of either zinc phosphate, gutta percha, or a combination of these two materials.

Use of Zinc Phosphate.—This material is usually employed in mounting crowns because of its marked adhesive properties, the promptness with which it "sets," and the strength of the attachment after "setting" has taken place. While strength of attachment, i. e., sufficient strength for retention, is a necessary quality of the retaining medium, the difficulty with which a crown, especially a dowel crown, is removed when mounted with zinc phosphate also constitutes an objection to its use. In fact, so emphatic has this objection to the use of zinc phosphate become, that many prefer the use of gutta percha. With the foregoing must also be considered the irritation to the dentinal fibrils, generally accepted as being due to the free phosphoric acid present in the mix, and which must be viewed seriously in proportion to the nearness of the pulp; and furthermore, the solubility of the substance in the fluids of the mouth. This latter disadvantage diminishes in importance in proportion to the accuracy of the adaptation of the crown to the root. If, as frequently occurs, the crown, either *jacket* or shell, is adjusted upon a vital tooth, the irritation of the pulp following the mounting of the crown due to the zinc phosphate not infrequently leads to secondary changes in the pulp, ending in its degeneration and death. This is a serious objection to the use of zinc phosphate as a "setting" medium. In many

instances the irritating effect upon the dentinal fibrils and pulp could be avoided if suitable precautions were taken. These consist in keeping the tooth dry and applying several layers of an impervious varnish, such as cavitin, rubber, or amber varnish to all the surfaces of the tooth to be mounted, *allowing each layer to thoroughly dry before applying the next.* This will be found to be, in most instances, a material aid in preventing the irritating impress of the cement from reaching the pulp. It is also necessary in using zinc phosphate, especially in canals, to maintain a state of dryness. This is usually accomplished by means of cotton rolls and by swabbing the canal with alcohol, followed by blasts of warmed air. The cement is mixed to a creamy consistency, a portion of which is placed in the canal, and by means of an instrument which will easily enter the canal, and a pumping motion, the cement is well worked into the canal; the interior of the cap and the dowel are then coated with the mix, and the crown forced to its proper position. It is well to support the crown when in place until crystallization of the cement is sufficiently far advanced to securely hold the crown. The technique for setting the gold crown is quite similar to that of mixing the zinc phosphate, protecting the material from contact with the oral fluids, and securing it in position until crystallization has taken place. It is also well to pass a flat burnisher beneath the margin of the gum and perfect the adaptation of the crown to the root. This also displaces particles of cement, which, if allowed to remain beneath the gum margin, might inaugurate serious pathological disturbances of the alveolar tissues.

Use of Gutta Percha.—The difficulty under which crowns are usually removed when set with zinc phosphate, as previously indicated, has inclined many to the

use of gutta percha as a means of retaining crowns and bridgework. The advantages from the use of this material for the purpose indicated are quite obvious. It permits ease of removal whenever this becomes necessary; it relieves the stress acting upon the root, also the porcelain, owing to its yielding tendency; it is insoluble in the fluids of the mouth, and non-irritating when used in relation to vital teeth. The chief disadvantage in its use is the time consumed in properly adapting the crown to the root. This also involves the use of a special heating contrivance, without which success is not probable. When intended for use the material is cut into strips, and these as well as the crown to be mounted are placed preferably upon an electric gold annealer (Dr. George Evans of New York introduced a gutta percha warmer for a similar purpose), and when sufficiently plastic the interior of the cap and the surface of the dowel are wiped with oil of cajeput or eucalyptol. A strip of the red gutta percha base plate, which is the variety of gutta percha used for the purpose here discussed, is then wound around the dowel, and a small piece is adapted to the interior of the cap; the crown with the gutta percha adapted to it is again placed upon the heater to maintain its semi-plastic condition; the canal may be moistened with heated water to prevent the gutta percha from adhering to it, and the crown forced into position. If the crown is readily forced into its correct adaptation with the root, it may be necessary to use an additional piece of gutta percha that all spaces might be completely filled. If, on the other hand, an excessive amount of material has been used, the surplus must be removed by means of heated instruments, or it may be impossible to correctly adapt the crown to the

root. When the proper amount of material has been finally determined, the crown with the gutta percha in position is again placed upon the heater, the canal thoroughly dried, and a small amount of chloro-percha worked into it; the crown is caught in the fold of a napkin and forced into position, and held in place until the gutta percha cools. Temporary stopping may be employed in the same manner, and, not being so refractory a material as gutta percha, considerable time may be conserved in its use. But the retention of the crown or bridgework is not likely to be as permanent; therefore, its use is indicated if for some reason it is thought best to temporarily set the crown or bridgework.

Use of Zinc Phosphate and Gutta Percha.—In some instances gutta percha fails to secure the crown permanently in position, owing probably to the excessive stress acting upon it. In these cases the advantages of each retaining medium may be utilized in combining them, and in this way securing the best results. In these cases the gutta percha is applied, as previously indicated; when the crown with the gutta percha adapted to it can be easily placed in its position upon the root, a soft, creamy mix of zinc phosphate is prepared, a portion of which is adapted to the canal walls and a portion applied to the surface of the gutta percha, covering the dowel and the interior of the cap, and the crown forced into accurate relation to the root. The adhesiveness of the cement will better retain the crown, and the gutta percha will admit of its comparatively easy removal whenever such procedure is indicated.

CHAPTER XXXIII

BRIDGEWORK

Definition.—Dental bridgework is the art of replacing lost teeth by attaching artificial substitutes to two or more natural teeth. The changes effected by the casting process in the general technique of artificial crown construction, as noted in the preceding chapter, are equally applicable in the construction of modern bridgework. Here, however, as in the consideration of artificial crowns, it may be of interest to briefly consider the history of bridgework, emphasizing the various progressive steps of its evolution, and, while many of these have been rendered more or less obsolete, with the advent of the casting process, a succinct reference to former methods is not only of interest, but necessary for the proper appreciation of the many advantages secured in the utilization of the latest methods.

History.—Attempts at bridgework can be traced to very remote periods. Specimens are to be seen in archeological museums which, considering the early state of civilization to which they belong, are capable of exciting our admiration for the development of a method for inserting substitutes for lost teeth, and for the skill displayed in the constructive effort. Figs 246-247 illustrate specimens of the earliest efforts in this direction.

In a work entitled "A Treatise on Dental Art," by F. Maury, published in French in 1828, an illustration

appears of six anterior teeth anchored to the cuspid roots which closely resembles quite modern methods. Figs. 248-249 is another illustration from the aforemen-

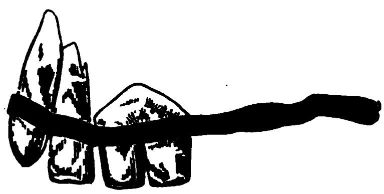


FIG. 246. (After Dr. Geog. B. Evans.)

FIG. 247. (After Dr. Geog. B. Evans.)

tioned work of an effort to replace lost natural teeth by securing substitutes to remaining natural teeth.

In 1855 Dr. Wm. H. Divinelle described a method of

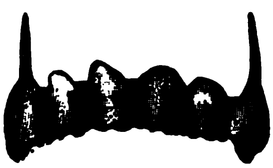


FIG. 248.

FIG. 249

adapting a plate to the end of the root and attaching an artificial tooth to it. "In this way a plate may be carried across an intervening space unoccupied by roots, and an unbroken row of teeth mounted upon it." This

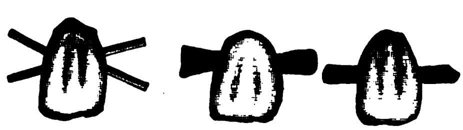


FIG. 250.—THE "BING" BRIDGE TOOTH.

has been referred to as "the progenitor of modern bridgework."

In 1871 Dr. Benj. J. Bing devised a porcelain tooth with a projecting platinum bar from each side (Fig. 250). The ends of the bar were to be secured in fill-

ings in the adjoining teeth. This was known as the "Bing Bridge."

In 1873 Dr. W. G. A. Bonwill introduced a form of removable bridge which may be considered an advance over anything preceding it. Dr. Bonwill's method consists of fitting a tube, threaded on its inner surface, to the root canal. Into this a threaded dowel was adapted to which an artificial crown was attached after being adapted to the root. An extension was adapted to the adjacent tooth to prevent rotation. The advent of the gold shell and the band and dowel crowns, for the elaboration of which we are indebted to Dr. C. M. Richmond, may be regarded as the beginning of modern bridgework, and, as this dates to about 1880, comparatively but a few years encompass the existence of the so-called modern bridgework. At the present time that system of construction which maintained its paramount position for thirty years again has been forced to yield its supremacy to methods productive of more satisfactory results. For these we are indebted to the casting process, and the perfection of the interchangeable tooth form.

We cannot dismiss this brief reference to the various progressive steps in the development of bridgework as practiced at the present day, without directing attention to the inlay method introduced by Dr. C. N. Alexander (see chapter on Inlays). The work of Dr. Alexander at least is worthy a position of equal import in relation to present methods, as the various methods introduced from time to time bore to the system of construction as practiced prior to the advent of the casting process. We do not wish to imply that Dr. Alexander's method had, or had not, any direct bearing upon Dr. Taggart's work. Upon this point we are not informed; but that inlays constructed after Dr. Alexan-

der's method to which iridio-platinum posts are attached may be effectively utilized as abutment pieces for supporting artificial teeth is now the satisfactory experience of many careful operators, and that the method may be employed as advantageously when the abutment teeth contain vital pulps, which makes it only necessary to use short pins so as not to menace the vitality of the pulp, as the method may be employed when the pin can be anchored in the canal, is also the conclusion of many operators sustained by a number of successful bridge pieces so supported. In the discussion of the different methods which will later follow, illustrations will appear of practical cases constructed upon this principle that have rendered eminently successful service.

Classification—Dental bridges may be classified as *fixed* and *removable.*

Fixed bridges represent forms of bridgework which cannot be removed from the teeth to which they are attached without more or less mutilation of the abutment pieces.

Removable bridges represent forms of bridgework which admit of removal from the abutment teeth without the mutilation necessary in the foregoing form, and which, when in position, are retained with sufficient security to render the service of mastication for which they are primarily intended. Removable bridgework owes its development to the serious objections which feature the fixed form of construction. In the latter form of construction perfect cleanliness is impossible. This unquestionably is a very offensive accompaniment of fixed bridgework, made particularly impressive to both patient and operator when such bridges are removed. This offensiveness is almost entirely eliminated

in the detachable form of bridge. The introduction of the interchangeable tooth form, and its utilization in the construction of bridgework, even prior to the advent of the casting process, materially diminished the unhygienic feature of bridgework in which the ordinary "facing" with an occlusal surface of gold was used to form the "dummy." Furthermore, whenever fracture of a facing occurred in the fixed form of bridgework, its removal for repair became necessary, unless the technique for making satisfactory repairs in the mouth had been acquired, and as these various methods for making repairs with the bridge in position had only been developed after the serious disadvantages attending the removal of bridges for the purpose of repair had strongly impressed themselves upon the profession, and as the technique for making a satisfactory repair with the bridge in position was mastered but by a small number, a loud and persistent demand for removable bridgework was plainly discernible. Furthermore, while in a properly planned bridge the abutments are usually adequate to meet the strain imposed upon them, in the removable form of construction, owing to the slight movement of which it is capable under stress, the strain upon the abutment teeth is correspondingly lessened, and, while this is regarded by some as a factor of importance, it must not be overlooked that the frequent removal of the bridge for cleansing purposes and its readjustment impose an additional strain upon the abutment teeth which almost negatives whatever value the former advantage may appear to possess. The advantages derived in the use of the removable type of bridge, however, were generally so advantageously considered, that whenever the case at hand admitted of its utilization, this form of construction was adopted. No fixed rules

can be formulated that may invariably guide us in making a choice between the two methods of construction. Each case should be carefully studied, and, if the removable form of bridge can be constructed for the case under consideration without incurring dangers to the abutments, it may be selected as the type of construction.

The conditions regarded as specifically indicating the use of the removable form of bridge were those in which considerable tissue had been lost, and therefore required extensive restoration, which could only be supplied in the use of a saddle, and which therefore required removal for hygienic reasons, and those cases where the remaining natural teeth appeared to be unequal to the mechanical demands of retention, and where contact with the soft tissue appeared to be desirable. But with the methods at our command at the present day, the saddle form is the invariable type of construction when replacing posterior teeth, and as the hygienic features of the modern fixed form of bridge are almost ideal, the conditions formerly regarded as indicating the use of the removable form of bridge are not now applicable with their former force.

Bridgework and Platework.—The arguments for and against bridgework have been presented with much earnestness and exhaustiveness. In this manner knowledge has been gleaned which is of material aid in determining which plan of restoration should be adopted. In a general way the advantages of bridgework have been summed up as follows: The comfort to the patient derived in the knowledge of the security of the artificial teeth; little, if any, interference with articulation, taste, etc. The remaining teeth (other than the abutments). as well as the gum tissue, suffer no ill effects, which

is not the case when a plate is inserted. Here the remaining teeth and the gum tissue suffer more or less injury, in many instances eventuating in loss of the remaining teeth, and in a pathological condition of the gum.

The disadvantages urged against the restoration of missing teeth by means of bridgework are: The mutilation of the abutment teeth and the destruction of vital pulps; the excessive strain imposed upon the abutment teeth, frequently resulting in their loss; the unhygienic conditions following the retention of food débris and other foreign matter. The latter objection may be dismissed, as the utilization of present day methods leaves little to be desired in the hygienic relations of modern bridgework, and compares very favorably indeed, to say the least, with the hygienic relations of platework. The former objections cannot be dismissed, as it is patent to all engaged in the application of bridgework that mutilation of the abutment teeth, devitalization of pulps, and finally loss of the abutment teeth do and may take place, even though the work is carefully planned. But the evil effects may be considerably lessened if the effort to acquire the details of the *mechanical* and *physiological principles,* upon which this depends, is earnestly exercised.

Mechanical Principles.—As the retention of the bridge depends upon its attachment to two or more natural teeth, the capacity of these for withstanding the excessive stress thereby imposed is a consideration of first importance. No exact rules can be formulated for determining the stress that may safely be imposed upon any tooth. This is due to our inability to express the vital aspect of teeth in definitely measured terms; but with the clinical knowledge gained through experi-

ence, and the increased knowledge at our command concerning the character and intensity of the forces acting upon teeth, we are enabled to proceed upon fairly safe lines in the construction of dental bridges, providing due regard is paid to the vital state of the retentive structures of the teeth, both in its normal aspect as well as in the aspect which the abnormal strain may develop. It is generally accepted that under normal conditions a cuspid or central incisor root will safely support an artificial lateral, providing that measures are taken against the displacement that is likely to take place if the free end of the lateral is not attached to the adjoining tooth. A molar, on the other hand, will carry a bicuspid even though the free end of the bicuspid is not fixed to the adjoining tooth. In these instances, while it is manifestly safe to depend alone upon the molar for the permanent retention of the artificial bicuspid, for reasons hereafter to be discussed, it is generally a better plan to attach the free end of the bicuspid to the adjoining tooth. In all instances the insertion of a bridge prevents the antero-posterior displacement of teeth commonly observed when the adjoining teeth are lost. In these cases, if the retentive structures of the teeth are normal, the insertion of a bridge and the extra stress thereby imposed upon the natural teeth are preferable to the displacement which otherwise surely will take place, and which is a potent factor tending toward their loss.

Another common example as to the necessity for a due regard to the related mechanical principles is found where the superior anterior teeth are replaced by attachment to the two cuspid roots. If the character of the occlusion and the length of the overbite are not carefully studied, and due provisions made for excessive

stress, failure will ensue. Dr. Bonwill[1] has shown the relationship between the length of the cusps and the length of the overbite. The deeper the cusps the greater the overbite and the greater the surface of contact; hence, the greater the stress upon the teeth. In these cases, if allowable, the length of the overbite may be reduced so as to diminish the lateral stress, or suitable resistance must be provided by making attachments to the bicuspids to meet the exigency of the case. It is almost needless to state, so well is it understood, that the additional presence of a central or lateral root would be entirely adequate to overcome any tendency to displacement.

The example furnished by the accompanying illustration (Fig. 251) needs scarcely more than a

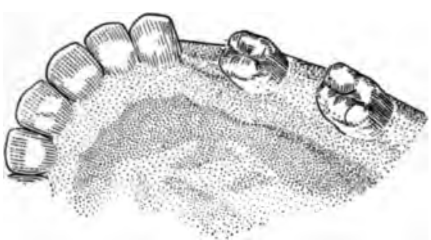


Fig. 251.

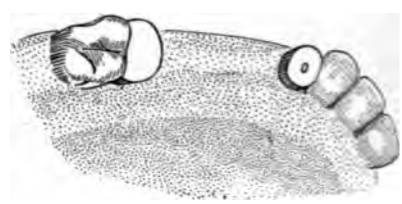


Fig. 252.

passing comment. The first and third molars will support the missing second molar and the second bicuspid without any support anterior to the bicuspid, excepting when made for reasons to be hereafter considered. The first molars and the cuspids will support all the missing teeth artificially replaced (Fig. 252). Many other illustrations could be given expressive of the principle here set forth, but with these the practitioner with even limited experience quickly becomes familiar.

While the foregoing statements have been made in

[1] "American Textbook of Prosthetic Dentistry."

application to the fixed form of bridgework, they are equally applicable to the removable form of bridge construction, although, as previously stated, it is claimed that the slight mobility of a removable bridge under stress somewhat reduces the strain upon the abutment teeth. For this reason some writers[1] believe that, within reasonable limits, in this form of appliance a greater number of substitutes may be supported by the abutments.

The foregoing mechanical considerations obviously involve the principles of stress and resistance in so far as these can be comprehended in dealing with vital structures. The mechanical requirements dealing with the preparation of the abutments, the dummies, the assemblage of the various parts into the whole constituting the bridge, etc., require little more than passing notice here. In discussing artificial crowns (see chapter on Artificial Crowns), complete information may be obtained as to these various matters. Emphasis may be made here as to the necessity for meeting the requirements in all particulars, if success is to attend the efforts of the operator, for it may be stated with a sense of positive conviction that in no other dental effort is compliance with exactness as stubbornly demanded as in the construction of a dental bridge.

Physiological Principles.—Here also the reader is referred to the section dealing with artificial crowns for detailed information as to these requirements. All foreign accumulations must be removed, and the gum margin and the canal placed in a perfectly healthy state. The question of the devitalization of the pulp, if the tooth contains a vital pulp, should be carefully considered. There appears to be an increasing number of

[1] "Principles of Crown and Bridgework."

practitioners who are in favor of devitalization in all cases where the tooth is to be prepared for the reception of a crown. While this, no doubt, is indicated in most instances, it should not be the practice to the exclusion of attempted pulp conservation, which the writers positively believe may at times be practiced with advantage to the patient. No invariable rule in this regard should be formulated. Each case should be carefully studied by the operator, and, if the indications point toward devitalization, this should be performed; but if the tooth, the age of the patient, etc., argue against successful canal treatment, and if no existing pathological state of the pulp can be inferred, its conservation may lead to a more successful result.

The continued apposition against the gum of a fixed bridge may lead to pathological manifestations of this tissue, which it need scarcely be stated are to be avoided. This may occur even though the bridge is faultless in its construction, and may be due to the pressure of the bridge against the gum, or the interference with its secretive function, when the tissue is predisposed to pathological manifestations, owing to previous disease or to systemic complications. Equally, if not more, important is the future relation of the bridge to the condition of oral hygiene. At the present time, when the serious effects of an unhygienic state of the mouth are so well understood and generally recognized, it is unpardonable to construct a bridge which will tend toward the inauguration of an unhygienic state beyond the degree established by the necessities of the case. Much of the odium attached to the insertion of bridges in the past has been due to the unhygienic state of the mouth with which their presence was related, and, while much of this could have been avoided by better workmanship

and a closer regard for the rules of oral hygiene, it is impossible to entirely eliminate bridgework as a factor of unclean mouths. But this need not pass beyond safe limits, especially since the advent of the casting process; therefore, at the present time, if the rules for dental bridge construction are closely observed, the hygiene of the mouth may be satisfactorily preserved.

In those cases where an artificial tooth is supported by a shell crown, as, for example, a second bicuspid supported by a crown placed over the first molar, and where the free end of the second bicuspid is in contact with the surface of the first bicuspid, unless the surface of the first bicuspid is protected, it will soon be attacked by caries. It is a much safer plan of practice to prepare a suitable inlay for the first bicuspid and attach it to the "dummy," so that when the bridge is placed in position the first bicuspid is afforded suitable protection against decay. The inlay should be anchored by means of a short iridio-platinum pin of about 18 gauge, and can be adjusted without menacing the vitality of the pulp.

FIXED BRIDGEWORK

Having carefully considered all the details of the case at hand, as indicated in the foregoing discussion, and concluded as to the best method of procedure, the consideration of the abutment pieces is next in order. Before proceeding with this, it may be stated that obviously the application of bridges to all sorts of possible conditions cannot be discussed. No field in dentistry offers a wider display for skill in overcoming obstacles than in the construction of bridgework, and in proportion as the capacity of the practitioner is adequate for the case, so will his success in these efforts be

determined. The scope of the present work admits of little more than the consideration of fundamental conditions. But the successful construction of bridges for these cases is an assurance that variable conditions can be successfully met, as the requirements are alike in all cases, irrespective of the deviations which special conditions may demand.

The Abutment Pieces.—Fixed bridges are secured in position by means of the *shell crown,* the *dowel crown, gold inlays to which an iridio-platinum post is attached, and the plate and post attachment.*

OPEN-FACE CROWN.—The so-called "open-face crown" (Fig. 253), which has so frequently been utilized in the past as the support for the anterior teeth of a fixed bridge, has now been almost entirely abandoned. Probably more teeth have been lost through the indiscriminate and careless use of this form of attachment than can be attributed to any other, and even when correctly adapted the presence of this form of crown in the anterior portion of the mouth can only be considered highly inartistic. At the present time we have safer and more artistic means for securing a bridge in this region, and the necessity for utilizing the "open-face" crown scarcely, if ever, presents. However, the indications for its use may arise where it is deemed unwise to remove the natural crown to replace it by a dowel crown, and where the other means of securing fixation for the bridge may not be practical, as may arise in teeth with exceedingly hypersensitive tooth structure, which cannot be controlled except by such means as are likely to endanger the vitality of the pulp. In these very exceptional cases the "open-face" crown may be constructed.

FIG. 253.

Procedure.—The mesial and distal surfaces of the tooth must be reduced to admit accurate adaptation at the cervical border. If the adjoining tooth is in close contact, sufficient space should first be secured by inserting a wedge, that the cutting disk may pass between the teeth without injury to the adjacent tooth. The lingual and incisal surfaces may next be reduced that the lingual portion of the crown may be adequately reinforced, and carried over the incisal edge to prevent its being forced rootward by the stress of mastication without interfering with normal occlusion. A piece of 29 or 30 gauge 22-k. gold is cut to the length of the wire measurement, and of a width at least equal to the length of the crown. This is adapted to the natural crown and the two ends soldered with 22-k. solder. The cervical end is next trimmed to follow the outline of the gum and adapted in the same manner as discussed in the construction of the shell crown. When this has been satisfactorily accomplished the labial and lingual portions of the band are trimmed, as indicated in Fig. 254. This reduces the band to the desired labial outlines and allows the lingual portion to be closely adapted to the tooth. A piece of 36 gauge pure gold is next closely adapted to the lingual surface of the tooth with the band in position, after which it is soldered to the band. The crown is now returned to the tooth, and if the adaptation is as desired the labial portion of the crown and the lingual part represented by the pure gold should be adequately reinforced with 22-k. solder. If the contact form is not restored as it should be, solder is flowed over the approximal portion of the crown in

Fig. 254. Fig. 255.

a manner to satisfactorily restore the contact. Fig. 255 represents the completed crown.

SHELL AND DOWEL CROWNS AND INLAYS.—For the consideration of the construction of the shell, the dowel crown, and inlays, the reader is referred to the different sections wherein these are fully discussed. It will only be necessary here to discuss such forms of anterior attachments as occasionally find application. While these attachments occupy a sphere of usefulness in some cases, it must be understood that their successful application depends upon the accuracy of the adjustment, and the appropriate stability of the construction. If these factors are not adequately considered it is impossible to secure permanent results. The accuracy of the adjustment signifies that when the attachment is in position no shoulder or space should exist for the lodgment of foreign matter, and this condition must be established not only in the construction of the attachment piece, but the necessary precautions must be exercised that it will be attained also when the completed bridge is placed in position.

The "staple" or "hood" crown, accredited to Dr. W. F. Litch, and the Carmichael crown, which closely resembles the former, are examples of the form of attachment pieces here under discussion. Permanent results are possible, as previously noted, with these forms of attachments, for which reason a description of the method of construction will follow; with the advent of Dr. Alexander's and Dr. Taggart's method, however, their application is rarely utilized.

Procedure.—By means of a thin cutting disk a groove is cut into the lingual surface at about the incisal third of the tooth extending from the mesial to the distal surface, and into the latter surfaces extending almost to the

gum line additional grooves are cut with desk and dentate burs at right angles to the lingual groove (Fig. 256). Platinum wire of about 18 gauge is fitted into the grooves, which are cut deep enough to accommodate the wire. A piece of 24-k. 36 gauge gold is next adapted to the lingual, approximal, and occlusal surfaces, and trimmed to the desired form. The plate and wire are now removed, and by means of solder the wire is attached in correct position to the plate.

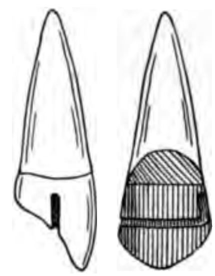


FIG. 256.

The hood may now be returned to the tooth and the adaptation noted; if not as desired it may readily be burnished to perfect adaptation, removed, invested, and reinforced by flowing solder over the plate. In the Carmichael attachment the gold is directly adapted to the grooves, after which it is reinforced by placing small sections of iridio-platinum wire in the grooves and flowing solder over the entire gold. A more desirable result is attained in the plate and pin form of attachments, as well as the hood form, if a piece of clasp metal is fitted to the cervical border of the gold and soldered to it. This materially strengthens the attachment piece. While this form of construction may be followed for any tooth, it is particularly applicable for the superior cuspids and first bicuspids, where the esthetic demand may emphatically inhibit the display of gold. Fig. 257 illustrates the completed attachment piece.

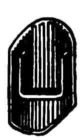


FIG. 257.

At the present time the casting method would be utilized in the construction of this form of attachment, greatly simplifying the procedure. A piece of inlay wax is softened and adapted to the tooth after its preparation, as previously discussed. The surplus wax is cut

away to the desired form, the occlusion secured, the wax model invested, and a casting made in the same manner as that followed in the construction of an inlay.

Construction of "Dummies."—It may be stated without fear of contradiction that the greatest benefits derived in the utilization of the casting method may be noted in its application to the construction of anterior and posterior "dummies" for bridgework. While the detachable tooth form, such as the Davis, has been used in the construction of dummies prior to the introduction of the casting process, and the esthetic effect thus secured is quite as good as that possible at the present time, the casting method has greatly simplified the technique of construction, improved the adaptation of the artificial substitutes, and materially added to the strength of the completed bridge. So apparent are these various benefits at the present time, as to make former methods now obsolete, thus reducing the practice of dental bridge construction to one general method of construction, which, very likely, will be followed for some time to come. That instances may arise in which former methods may still find application is not to be doubted, but these will prove the exceptions to the general method in vogue, of which the casting process will be the dominant feature. In order to better define the advantages obtained in the utilization of the casting process in the construction of bridgework, former methods will be briefly discussed. This will enable the reader to make direct comparisons, and perhaps refresh his memory as to the steps of procedure, should one of these be applicable to a case in practice.

ANTERIOR "DUMMIES" AND "ABUTMENT PIECES."—For many years the ordinary "facing" was utilized in replacing any of the anterior teeth. These are supplied

by the dental houses in such varied forms that almost all conditions can be successfully met. In this regard the "facing" is almost beyond criticism. Its great deficiency is to be found in its inability to resist the forces of mastication, attested by the large number of fractures that have occurred in those cases where the anterior teeth have been replaced by the so-called "facing." The many failures finally induced a number of bridgeworkers to abandon the use of these facings for anterior replacement of missing teeth, and in their place to utilize the stronger "plate" tooth. But as these did not admit of the wide range of application characteristic of the former, and in many instances of a long over-bite, as their employment is contraindicated owing to their increased bulk, recourse to the use of the weaker facing was the only alternative. When the case has been set up on the articulator, and the facings ground to the desired position, its incisal, or occlusal, edge is beveled and the backing extended over this. This provides a degree of protection for the porcelain against the stress of mastication. The pins should not be bent to hold the backing in position, as this is likely to result in fracture of the porcelain, but it is better to shave a section of the pin by means of a sharp instrument, as indicated in the discussion of artificial crowns. This is as adequate for holding the backing in position as the method of bending the pins. Care should be taken not to grind the facings in actual contact with each other, but to provide slight space for the changes of form taking place in the porcelain during the soldering process. If these rules are observed very satisfactory results may be obtained.

The introduction of the Davis Crown, and its quickly proved general efficiency, together with the facility with which repairs could be made, owing to its replaceable

or interchangeable feature, soon led to its adoption in the construction of anterior "dummies," and where not contraindicated, as, for instance, when the bite is very close, or when the remaining natural teeth are very short, soon proved to be a decided advance in the construction of bridges.

The method of procedure is as follows: The roots are prepared as previously indicated, and ground to a line slightly beneath the gum border. The cap is prepared in the usual manner, and the dowel soldered to it as discussed in the consideration of artificial crowns. That portion of the dowel extending beyond the floor of the cap should be removed (Fig. 258). When the caps are constructed as indicated, they are placed in position upon the roots and a bite and impression secured. The interior of the caps should be coated with a thin layer of wax to facilitate subsequent removal from the model.

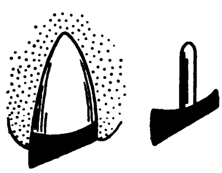


Fig. 258.

The model and bite are then mounted upon the articulator. The selected crowns are next suitably ground, and when adjusted, the base of the crown must be ground away to admit of sufficient gold to support the crown and adequately strengthen the cap. The approximal surface of each crown toward the dummies is also ground to allow adaptation of the gold, thus providing a greater soldering surface necessary for strength and adding to the hygienic features of the completed bridge. A backing of pure gold, 34 gauge, is next adapted to the base and sides of the crown. The gold covering the base of the crown is perforated for the reception of the dowel which, when fitted to its proper position, is secured in place and soldered to the backing. The dowel and backing are returned to the crown, carefully adapted, and

all surplus removed. This includes the removal of all that portion of the dowel extending beyond the crown, which, of course, is not needed, as the completed crown is retained by means of the dowel attached to the backing. The crown with the backing in position is now properly related to the cap upon the model and this relation secured by means of hard wax. The two are removed from the model, the crown carefully detached, and the cap and backing soldered together (Fig. 259).

Fig. 259.

When the attachments for the roots are completed, they are placed in position upon the model with the Davis crowns in place. The dummies are now prepared, the process practically being a repetition of that just described (Fig. 260). To those conversant with the application of the casting process in the construction of bridges, the complexity of the foregoing is at once made evident.

Fig. 260.

Steele's Interchangeable Bridge Tooth.—This form of removable facing appears to have grown in favor in some quarters in its application to the construction of anterior dummies. But its use should be carefully related to the forces likely to act upon it, and if these appear to be above, rather than below, the average of the forces of mastication, this form of facing is not likely to prove permanent. The Steele facing has a dovetailed slot in its lingual surface, to take the place of the platinum "rib" found in the original mason facing (see illustration). This was soon determined to be an element of weakness. This change has been of great value in the re-

sistance capacity of the Steele facing. This dovetailed slot engages a corresponding metal projection which forms part of the backing—similar to other forms of facings with specially prepared backings, like the "Dwight," "Roach," etc., the surface of the backing which engages the porcelain must be kept free from solder during the soldering together of the different parts. Fig. 261 illustrates a practical case.

FIG. 261.

The Casting Process in Relation to the Construction of Anterior Dummies.—Here we find what at the present time constitutes the ideal method of construction, if the condition admits of the use of the Davis, or similar crown. If this form of crown is not indicated for the anterior replacement, then the use of Steele's facings, from the consensus of many bridgeworkers, appears to be indicated. More recently Dr. Goslee has introduced a pinless tooth facing, which offers "a maximum degree of strength, the thinness usually demanded in application to the replacement of the eight anterior teeth, and all of the advantages of the replaceable form of tooth combined." These facings contain holes in the same relation to the facing and to each other, as the pins of the ordinary tooth facing. The holes have a slight shoulder at the surface similar to the Davis crown, and are slightly countersunk at the lower ends. The shoulder at the surface receives the thin diaphragm located at the center of the pin, one end of which is attached to the cast metal backing, and the other receives the facing. This arrangement provides all the advantages of any of the replaceable tooth forms.

Having prepared the model with the attachment pieces in position, secured the bite, and mounted these upon the articulator, the form of tooth best adapted for the case is selected and ground to meet the requirements. The form introduced by Dr. Goslee, no doubt, will find a wide range of application. In the authors' judgment the tooth form designed by Dr. Goslee to take the place of the Davis, or similar form, for the anterior portion of the mouth, is no stronger than the teeth, the place of which it is recommended to take, for all practical cases. The authors are about to introduce a new form of attachment for pinless teeth, also tooth form, in the utilization of which a stronger crown can be prepared than heretofore obtainable for the anterior teeth. The Davis and similar crowns satisfactorily answer the requirements when used in the ordinary manner, but when ground in the lingual region, and upon the lateral surfaces, in order that a suitable casting might be prepared for the base of the crown, the lingual portion of the crown, at the basal end, is made conspicuously weak, attested by the many fractures that occur in practice. To obviate the grinding and consequent weakening of the porcelain crown, and at the same time furnish a cup arrangement similar in effect to a casting is the purpose of the authors' device.

Fig. 262 illustrates an improved tooth form best adapted for the device, also the device itself. The opening in the crown for the reception of the pin is arranged for two sizes of pins. In small teeth the opening in the crown is only intended for an 18 gauge pin. This allows of a greater bulk of porcelain, therefore greater strength. The second size is intended for larger teeth and will admit a 16 gauge dowel. The device is constructed of platinous gold in the form of a staple perfo-

rated at the top for the passage of the pin. The perpendicular pieces approximately fit the grooves upon the lateral surfaces of the crown. When intended for use the root is prepared in the usual manner, and the cap and dowel adjusted. A suitable crown is then selected and made to conform to the labial end of the cap. A piece of 24-k. 36 gauge is adapted to the base of the crown and allowed to extend into the grooves upon the lateral surfaces. The staple is then forced into position upon the crown. In so doing it forces the gold plate into close adaptation with the grooves, and later when the staple is attached to the gold plate with solder the adjustment of the staple is as perfect as that of a casting. The dowel, either 16 or 18 gauge, to correspond to the opening is next selected, forced through the perforation at the top of the staple and the gold plate, which has been previously adapted to the base and into the lateral grooves of the crown. When the dowel has been adjusted to position, it is secured in place by means of wax, invested, and permanently attached with solder. The solder is also made to flow along the gold, which fits into the grooves of the tooth. The projecting end of the dowel is cut away, the porcelain crown, with its staple attachment in place, is adjusted to the cap, sustained in position with wax, removed with the cap in place, the porcelain crown is disengaged from the staple, the staple and cap invested, and soldered.

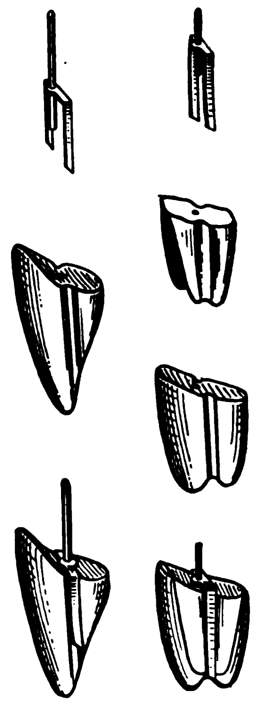


Fig. 262.

When completed, all the desirable features of the interchangeable type of tooth with the cast base characterize the crown and staple attachment just described, and, in addition thereto, it possesses the quality of strength and simplicity in much greater degree than any other form of anterior crown when prepared for a cast base.

If the Goslee facing is selected, each tooth after being properly ground, including the incisal bevel, is to have its lingual surface coated with glycerin, the pins placed in position, and inlay wax adapted to form a suitable backing. When this has been accomplished the teeth with the wax backings are returned to their proper places upon the model and secured in position by means of wax. Any additional carving of the backings may now be performed. Each facing is next carefully removed from its wax backing, the wax mould invested, and a casting made in one piece, which can be done quite readily for three or four facings. When the casting has cooled, it is placed in the acid bath, cleaned and finished. The facings may now be adjusted to the backing, and both placed in proper position upon the model. This is necessary to determine the exact relation of the backing to the attachment pieces to which it must later be attached with solder. It is a safer plan to pour the model with an investment material, so that the soldering may be done without disturbing the exact relation of the attachment pieces. If this plan has been followed, it is but necessary to remove the facings from the casting, after the correct adjustment has been made upon the model, secure the casting in position by the addition of investment material, and solder to place, using a minimum amount of solder. The attachment pieces, with the backings soldered in position, are next placed in the acid bath, satisfactorily cleaned, the facings cemented

in position, and, when thoroughly set, the final finishing made, and the case set to place in the arch. A decidedly advantageous feature accompanying the use of the replaceable tooth form in bridgework consists in grinding a duplicate tooth, so that, in case of fracture, it is but the work of a few moments to cement the duplicate tooth in position. If this is not done a record should be made of the color and mould of the tooth used, otherwise considerable difficulty may be experienced in making repairs. If, in place of the facing previously considered, the case at hand admits of the use of the Davis or similar crown, the advantages of increased strength and esthetic effect, gained in the use of this form of tooth, should influence the choice in its favor. The indication of the use of this form of tooth is determined by the occlusion and the degree of the alveolar resorption, which may admit of the use of a saddle and the heavier tooth form.

When the indications are favorable for the use of this form of tooth, the procedure is as follows: An impression is taken with the abutment pieces in position, and the bite secured. These are mounted upon the articulator and suitable crowns selected. Each crown is ground to meet the requirements of the case, and further ground upon the lingual and approximal surfaces that the casting wax may be moulded to the form necessary for strength and protection of the casting in regard to the finished bridge and to the individual crowns. Each crown after being ground in this manner is oiled. If the pin is to be cast with the base, the interior of the opening within the crown is slightly enlarged, also lubricated. The softened casting wax is forced into this opening and over the surfaces of the crown. When each tooth has been prepared after the manner indi-

cated, they are assembled upon the model, properly adjusted to the abutment pieces and the occlusion and secured in place by wax previously placed upon the model. The wax is now carved to the desired form with special regard for the lingual contour, after which each porcelain tooth should be removed from its wax encasement without distorting the wax model. The precautions in this regard must be as rigidly observed as in the construction of an inlay, if satisfactory results are to be attained. The wax mould is next removed from the model, invested, and the casting prepared as previously indicated. The succeeding steps toward completion of the bridge are similar to those previously discussed in relation to the utilization of the facing.

Comparing the procedure noted above and the results thereby attainable with those preceding it, no doubt can possibly remain that the very highest results possible in bridgework, at the present time, are to be obtained by this method. The comparative simplicity of the procedure, its superior hygienic features, its greater esthetic effect, its stability, and the readiness with which repairs can be made combine to give it a preëminent position among the methods of dental bridge construction, which in all likelihood it will occupy for years to come.

Posterior "Dummies."—The advantages secured in the construction of "dummies" for anterior replacement by the present methods are greater when applied to the construction of posterior dummies. In briefly discussing the methods followed in the past, which plan was adopted in the consideration of the different methods of construction of anterior dummies, the tremendous advantages secured in the utilization of the casting process, and the replaceable tooth form, in relation to the con-

struction of posterior dummies, may, in this manner, be better emphasized. The ordinary "facing," so conspicuous in the past in replacing anterior teeth, is equally available in replacing the bicuspids and molars. But here the method of construction is more complex than that appertaining to the anterior teeth, owing to the occlusal surface which it is necessary to add to the facing for posterior replacements, and which, obviously, is absent in anterior dummies.

Procedure.—The abutment crowns being completed, an impression is taken with these in position, and the bite secured. The model is poured, and both are mounted upon the articulator. Suitable facings are selected and ground to the requirements of the case, which include the reduction of the occlusal form of the facing to provide the necessary space for the addition of the gold cusps. When this step in the procedure has been completed, each facing is to be backed with pure gold, 34 gauge, closely adapted from the shoulder of the facing to the occlusal edge, and approximally, and a slight surplus of gold should be allowed to extend beyond the occlusal edge, to permit of a correct adaptation of the gold cusps, and also admit of the solder flowing between the two pieces of metal that a flush joint may be made when finishing.

The occlusal surface may be formed in various ways, the most accurate results, however, are secured when special cusps are constructed, which plan is usually recommended by the most careful bridgeworkers. In adopting this method of cusp construction, the facings after being backed are waxed in position from their buccal aspect. The model being shellacked, plaster is mixed and adapted against the backings, and the articulator closed. When the plaster has set, the articulator is opened and the impression of the antagonizing cusps

will be obtained. The plaster cusps may now be trimmed to the desired form, separated by means of a fine saw at the line where the facings approximate, and a die and counter die constructed for the cusps of each facing.

When the gold cusps have been formed, they are adapted to the facing in a manner that will result in a narrow buccal edge of gold, which is secured by cutting away the anterior portion of the swaged cusps (Fig. 263). This is a marked improvement over the

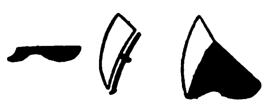


Fig. 263.

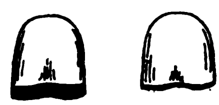


Fig. 264.

former method of grinding the occlusal edge of the facing flat and adapting thereto the gold cusps of uniform thickness. The difference appears in Fig. 264.

When the satisfactory adaptation of the gold cusps to each facing has been maintained by the use of wax, the facing is invested and soldered, and the dummy completed. After the completion of each dummy, they are assembled upon the model, secured in their proper position, invested, and the case completed. Bridgework constructed after this manner has yielded very satisfactory results in the practical application of the replacement of molars and bicuspids. Its principal objections, as previously noted, are sustained in the difficulty with which repairs are made, and its unhygienic feature. The advancement made in these relations, in the utilization of the present methods of construction of posterior dummies, will be better emphasized in describing the method.

The Casting Process in Relation to the Construction of Posterior Dummies.—When the model with the at-

tachment pieces in position and the bite have been mounted upon the articulator, a suitable replaceable tooth, such as the Davis Crown, or that made by Justi, or the S. S. White Co., or the Pennsylvania Dental Mfg. Co.,[1] is selected and ground to the requirements of the case. The precaution of grooving the sides of the crown must here be as thoroughly observed as was discussed in relation to the anterior teeth, in order to secure the maximum degree of strength. When the crown has been adjusted by grinding it is lubricated with oil or glycerin, the casting wax heated and adapted to the crown, as previously discussed in relation to anterior crowns.

If a special pin is to be used, the opening and lingual surface of the crown is lubricated, a piece of iridio-platinum wire adapted to the opening in the crown, and secured in position by flowing melted casting wax about the extended end of the pin, and adding the wax to cover the entire lingual surface. The pin and backing can be cast in one piece here, as well as in the construction of dummies for anterior replacement. The procedure is precisely similar to that discussed for the anterior teeth. When each crown has been prepared as indicated, all are assembled upon the model and secured in position by the wax previously adapted thereto. The desired trimming of the wax is now done, and when satisfactorily attained, the porcelain crowns are carefully removed from their wax encasement and the casting made as previously described. When this has been removed from the investment, and cleaned, each porcelain crown is fitted to place and the piece finished up to the final polishing. It is next accurately adapted to the model, secured in position by means of wax, the porcelain

[1] Dr. Goslee's new tooth form is also designed for molars and bicuspids.

crowns removed, the investment added, and the backing soldered to the abutment pieces, after which the final polishing may be done. When the model is made of an investment compound, as it should be, it is not necessary to remove the abutment pieces and backing, hence the danger of displacing any of the parts to be soldered together is avoided. In those cases where the crowns of the teeth are very short and considerable stress acts upon the teeth in mastication, it may be deemed advisable to provide a surface of gold in the construction of posterior dummies. This may be done by utilizing the casting process in relation to the ordinary facing. Having the case mounted upon the articulator, as previously noted, suitable facings are selected and ground to meet the requirements of the case, including the occlusal bevel. The lingual surface of the facing is next lubricated and softened inlay wax adapted thereto. When each facing has been prepared in this manner, they are immersed in heated water, returned to the model, secured in position by the wax previously placed there, the jaws of the articulator quickly closed to secure the impression of the antagonizing plaster teeth, which previously have also been lubricated. When the occlusion has been satisfactorily established, and the wax carved to the desired form, the facings are carefully removed from the wax, the wax model detached from the articulator, carbon points adjusted to the openings in the wax made by the pins of the facings, invested, and the casting made. This is later soldered to the abutment pieces and the facings cemented in position. In case of subsequent fracture a duplicate is quickly adjusted to position.

Bridgework with an Interrupted Relation Between the Dummies.—Heretofore we have considered only

those cases of fixed bridge application where all the artificial substitutes are in direct contact with each other. Cases may arise, however, where a natural tooth may remain in the arch, which is not required for anchorage, or which, owing to its position, cannot be utilized as an abutment. The adjustment of a bridge in these instances involves an interruption in the continuous relation between the dummies, and the term "interrupted bridge" has been applied to such forms of construction.

In the construction of this form of bridge the connecting bar should have adequate strength on each side of the tooth remaining in the arch, and its relation to the natural tooth should be such that cleanliness of the parts can be easily maintained. Iridio-platinum wire of about 15 gauge with its ends flattened is usually employed and so adapted that it is not in direct contact with the tooth remaining in the arch. It is questionable whether, with the methods at our command at the present time, it is ever necessary to construct this form of appliance. Figs. 265 and 266 illustrate this type of construction. In the first illustration the likelihood of caries appearing at a point adjacent to the contact of the artificial teeth with the natural tooth is quite obvious. For this reason it might be better practice to prepare the natural tooth for an inlay with a short iridio-platinum pin at each end. This could be made sufficiently strong to support the artificial teeth with the aid of the crown fitted to the bicuspid. In the second illustration it might also be questioned whether it would not be better practice to adjust two separate bridge pieces, with an inlay and pin anchored

Fig. 265.

to the central incisor and second bicuspid, and these, with the aid of the dowel crown adjusted to the cuspid, would be entirely adequate to permanently anchor the artificial lateral and first bicuspid. Notwithstanding the questionable application of this type of construction to the cases furnished in the illustrations, instances may

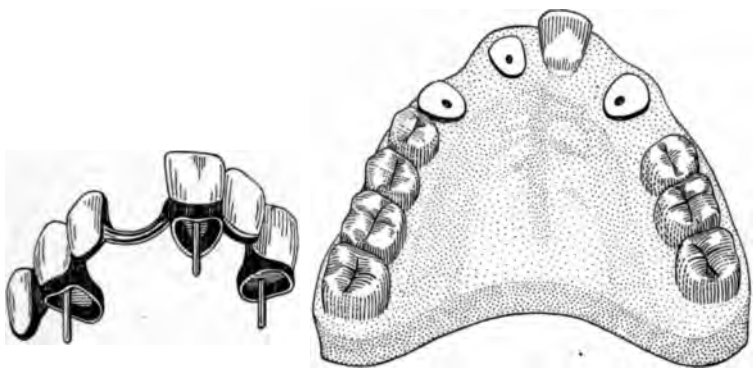


FIG. 266.

arise where the inlay and pin attachment could not be utilized owing to an exceedingly hypersensitive tooth structure, and where it appears prudent not to devitalize in order to make such construction possible; in these exceptional instances the so-called interrupted bridge structure as previously described may find suitable application.

SADDLE BRIDGES.—As formerly classified, a "saddle bridge" implied that form of construction which involved the adaptation of metal to the gum tissue, and which subsequently was attached with solder to the abutment pieces, and to which the dummies were attached. The adaptation to the ridge was secured by swaging the plate between a die and counter-die formed by pouring a fusible alloy directly into the impression,

and subsequently forming the counter-die of the same metal; or the adaptation may be secured by directly conforming a thin piece of platinum or 24-k. gold to the model and subsequently reinforcing with solder. This form of bridge was indicated where excessive resorption had occurred, in which cases satisfactory restoration and adaptation could not be secured in any other manner. It was also indicated in those instances where one or more dummies subjected to stress and carried beyond an abutment, with but one end attached, required the support of the ridge, without which a permanent result could not be reasonably anticipated. As an example of the effective application of the casting process, with a comparative simplicity in the technique of construction, no condition can better serve to emphasize these features than those indicating the use of the former "saddle bridge." This applies also with equal emphasis to the decisive manner in which the present-day method of the casting process has supplanted former methods of bridge construction. It would be unpardonable for any one to adopt the former complex method of constructing a bridge to meet the indications here discussed, when far superior results can be produced under a greatly reduced complexity of technique and which can be mastered with less difficulty than the former. The application of the casting method to these cases is precisely similar to that previously described, after due attention is paid to the degree of restoration necessary, owing to the extensive resorption and to the adaptation. Fig. 267 shows a case of extensive resorption which formerly imperatively called for the formation of a saddle, as described, to which the dummies were subsequently attached. At the present time complete restoration would be made by carving the wax to the desired form, care-

fully removing the replaceable crowns, investing the wax model, and preparing the casting as previously indicated.

EXTENSION BRIDGES.—As previously defined, an extension bridge represents that form of construction in which one or more "dummies" are extended beyond an abutment, and are adjusted with or without a saddle. This type of bridge, as formerly planned, for sufficient reasons is generally condemned, excepting in those cases where but one tooth is extended, as, for instance, a bicuspid dummy attached to a molar shell crown, and for which the one tooth alone is adequate for permanent retention, although, as previously stated, it is a far better plan also to secure attachment to the bicuspid by means of an inlay and short iridio-platinum pin. The present use of the heavy iridio-platinum bar, attached to the abutment piece on one side and the saddle of the extension upon the other side, or to the two ends of the saddle, if one is used for each side, has materially enlarged the scope of the application of this type of bridgework, and gives promise of great permanency, with all the advantages which the bridge form of replacement possesses over a plate.

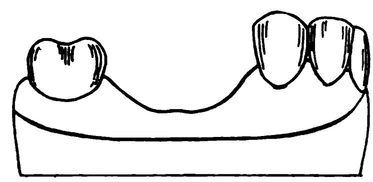


FIG. 267.

Fig. 268 illustrates a case appearing in the "American Text-Book of Prosthetic Dentistry" presumably from the practice of Dr. Parr. In this case the six superior anterior teeth appear with but one-third of the crown remaining, the other portion having been lost through abrasion. Richmond crowns were constructed for the central incisors and cuspids, and by constructing saddles for the ridge in the region of the molars an en-

tire bridge was constructed for the case. No record is at hand as to the service rendered by the appliance, but it is quite obvious that if a heavy bar were attached to the saddles, as will be described later, the stress upon the abutment roots would have been relieved, and the per-

Fig. 268.

Fig. 269.

manency of the bridge materially increased, the other factors being equal. The authors have constructed a number of extension bridges with the end of the saddle secured with the heavy iridio-platinum bar, the other end of which was attached to the abutment piece, and these are still rendering very efficient service.

The following is a case in practice constructed upon this principle.[1] All the teeth upon the left side are in place, the bicuspids being badly impaired. Upon the right side all the teeth posterior to the first bicuspid have been lost. Shell crowns were constructed for all the bicuspids, which the authors concluded to be ad-

[1] The patient's failure to conveniently arrange for an appointment that an impression might be secured showing the appliance in position accounts for the non-appearance of illustrations of this case.

missible in this case, owing to the complete manner in which the first bicuspids were hidden from view by the long lip and heavy moustache of the patient. When the crowns were perfectly adjusted to the teeth and to the occlusion an impression was taken, and the model poured with an investment compound. The saddle was subsequently constructed for the support of the teeth to be added by adapting pure gold, 36 gauge, directly to the model. When this conformed to the requirements iridio-platinum wire of 12 gauge, with its ends flattened as previously directed, was adapted to the roof of the mouth in a manner just to escape direct contact with the soft tissue. The ends of the wire were subsequently soldered to the saddle and to the crowns upon the other side. As the saddle must be later detached from the bar, that the casting may be made directly to it, but a small quantity of solder should be used in making the attachment. When the bar had been attached to the saddle and the crowns it was removed from the model, placed in the acid solution and, when thoroughly cleansed, adjusted to the natural teeth. When the required adjustment had been made, an impression and bite were taken, and, before pouring the model with the assembled parts in position, the interiors of the crowns were coated with melted wax to facilitate the removal of the piece from the model for the purpose of detaching the saddle from the bar, as previously stated. The model and bite were then mounted upon the articulator, suitable Davis crowns selected, ground to the requirements, which necessarily includes the subsequent relation of the cast base to the crown, as discussed in the consideration of posterior "dummies." When this had been satisfactorily attained, and the casting wax applied to each crown, these were assembled upon the sad-

dle, with the detached bar in position, the wax carved to the desired form, the bar removed from its position, followed by the careful removal of the crowns from their wax encasement, and the casting made direct to the saddle, as previously indicated. Later the bar was again soldered in its proper position.

FIG. 270.

Fig. 270 illustrates a practical case showing the application of the principle of an extension saddle, supported by a bar attachment. In this case, upon the left side, the teeth posterior to the cuspid have been lost; upon the right side, the teeth posterior to the cuspid have been lost excepting the second molar. The anterior natural teeth were considerably worn down, so the pulps were removed and the roots prepared for crowns. Steele facings were utilized owing to the greater space they afforded for the attachment of the box form construction to the lingual surface, into which a bar is fitted projecting from each end of the saddle. The bar is made into a spring by having a piece of platinous gold soldered to the bar at its saddle ends. The second molar was prepared for a

FIG. 271.

telescoping crown. The illustration shows the Steele facings cemented in position, also the anterior box attached to their lingual surface. It will also be noted in this case that a heavy square iridio-platinum wire is attached to the cuspid and molar upon the right side, and is extended from the left cuspid posteriorly to the position occupied by the first molar, a connecting wire is then conformed to the palatal outline and attached to the molar crown upon the right side and to the end of the wire upon the left side. This arrangement was made necessary by the patient's emphatic insistence upon having the anterior teeth permanently attached in position and separate from the posterior teeth. The arrangement as noted above realized this, and at the same time provided the foundation for the saddles supporting the posterior teeth. A piece of 36-gauge platinum plate is next adapted to the ridge and over the bar attachment, making a box-like arrangement into which the bar accurately fits. The same procedure is applied to the left side, and the box-like arrangement is also made for the palatal bar. The palatal bar is constructed of half-round platinous gold wire, about 11 gauge. The bars extending parallel with the ridge on both sides are constructed of square wire, about 12 gauge. The telescoping crown is next constructed and, when satisfactorily adjusted, suitable detachable crowns are selected and ground to the requirements of the case. With the platinum saddles in position, wax is softened and adapted to the crowns and the surface of the saddle for a casting, as previously discussed. When the casting for the crowns has been made for each side, each piece is separately finished. This applies to the box form into which the palatal bar fits. When the different parts are satisfactorily finished they are assembled in position, per-

manently attached with solder, and the final finish given to the piece.

REMOVABLE BRIDGEWORK

As previously defined, removable bridgework represents that type of construction which admits of removal from the abutment teeth without mutilation, and which when in position is retained with sufficient security to render the service of mastication, for which the bridge primarily is intended. The development of this system of replacement of lost teeth is largely due to the uncleanliness of the former type of fixed bridgework, and to the difficulty with which satisfactory repairs were made. But the introduction of the replaceable tooth, and the casting process, has, in a great degree, reduced the former need of an improved type of construction, and while the removable form of appliance still possesses advantageous features over the present form of fixed bridgework, these features, in regard to cleanliness, are not now as strongly marked as formerly. Nevertheless, as a better oral hygiene can be maintained with the removable form of bridge, this in itself is sufficient reason for its employment, whenever this can be done without incurring dangers in any direction, aside from any other advantage that may accrue from its utilization.

The means by which the removable feature of this type of construction is attained has engaged the inventive ingenuity of many members of the profession ever since its advantages were first recognized, consequently many methods have been presented and many devices patented, nearly all of which failed to successfully accomplish the purpose for which they were intended. These have disappeared excepting as a memory with some of the older members of the profession. The

clasp with its occlusal rest is spoken of as a "removable" attachment and its utilization in a method of replacing lost teeth is regarded as constituting a form of "removable bridgework." In the writers' judgment this is not "removable bridgework" in the general comprehension of the term, and may properly be included in the discussion of platework. The deep saddles constructed for the support of the artificial substitutes and the direct application of the clasp to the natural tooth are precisely similar to the principles of the platework as practiced for many years. While it may be almost impossible to demarcate clearly as to what constitutes removable bridgework, no type of construction which has its "removable feature" directly applied to the natural tooth ought to be placed in the category of "removable bridgework."

In bridgework, whether fixed or removable, an important desideratum is to permanently safeguard the abutment tooth against caries. This cannot be accomplished when a clasp is directly applied to the natural tooth. No matter how perfect the adaptation, or what means of cleanliness may be adopted by the patient, sooner or later caries will attack the teeth to which the clasps have been attached. For this reason this form of construction has been almost entirely abandoned by the writers. When suitable means, however, are adopted for protecting the abutment teeth, as may readily be done by first adapting a shell crown, which is cemented upon the natural tooth and to which later the clasp is fitted, this type of construction occupies a useful field, and more properly belongs to the form of appliances designated "removable bridgework." In constructing the crown in these cases, it is best to use 28 gauge gold plate. This is somewhat heavier than that recommended when discussing the construction of the shell crown for which 29-30 gauge was sug-

gested, but as the frictional effect of the clasp must now be considered, it is a better plan to use the heavier gauge metal. The form of the crown should be constructed with the view of the subsequent adjustment of the clasp, therefore but a slight contour should be formed, otherwise the proper adjustment of the clasp cannot be obtained. In shaping the natural crown provision should also be made for the occlusal rest of the clasp by grinding the desired form into the occlusal surface. This form is reproduced in the crown and into this the rest is fitted and subsequently attached to the clasp (Fig. 272).

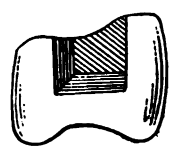


Fig. 272.

Of all the means presented for the construction of removable bridgework the tube and split post and the telescoping crown principle offer the widest range of application and the greatest reliability. When the removable bridge involves an anterior abutment, no method of construction offers the advantages secured in the utilization of the tube and split post method.

Tube and Split Post Method.—The root is prepared as previously discussed in the construction of the dowel crown. A piece of 30 gauge 22-k. gold is adapted to the end of the root projecting beyond the gum, and when its ends have been joined with solder it is trimmed to conform to the outlines of the gum. When this has been done the band is removed, the root ground down labially, that the proper esthetic effect may be secured in the finished crown, the band returned to the root, and the line of the root marked upon its inner surface. The canal is next enlarged to accommodate the tube to be used. The tube is prepared by turning a piece of 34 platinum plate around a post of the same gauge as the

post of the crown to be constructed. When the two ends of the platinum, one of which has been beveled, come together around the wire, the wire is withdrawn, borax applied, and by means of a small piece of platinum solder the two ends of the platinum are united to form the tube. The surplus plate is cut off, one end of the tube closed by soldering a piece of platinum to the tube, and the end rounded that it may be fitted to the canal. A plaster impression is now taken with the band and tube in position, melted wax applied to the inner portion of the band and over the surface of the tube to facilitate its subsequent removal from the model, and the model poured. When the model has been separated the band is cut down to the line of the root previously marked upon its inner surface, and when trimmed flush with the end of the root, having removed the tube, a piece of gold to form the floor is soldered to the band. This is later perforated, the tube adjusted to position and soldered to the cap. The portion of the tube extending beyond the floor of the cap is trimmed down, and the piece finished and polished (Fig. 273).

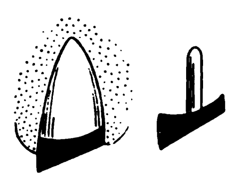


Fig. 273.

The removable part is constructed after the following method: A piece of half-round platinous gold wire is bent to bring the flattened surfaces together, and the free ends united with a minute piece of solder. It is then filed to exactly fit the tube previously constructed. A piece of platinized gold (crown metal), 28-30 gauge, is perforated so that the post will fit tightly. This is adjusted to position, and with the post in place the relation is sustained with hard wax, removed from the tube, invested, and soldered. When cleaned it is returned to its position and the floor trimmed to correspond with

the floor of the cap previously constructed. When this has been satisfactorily accomplished, an impression and bite are secured with the tube and the removable part in position, the model poured, a suitable replaceable crown selected, ground to the requirements of the case, casting wax adapted to its base and to the cap, and a casting made according to the method previously discussed. The cap and tube are cemented to the root. The removable part, which now is a part of the cast base, is later attached to the dummies.

The principle of tube and split post may also be utilized in constructing attachments for molar teeth, and its application may be made when either the telescoping crowns or an inlay is used as the abutment piece. Some writers [1] do not regard simple telescoping crowns as generally successful in their application to removable bridgework. This is not in accord with the writers' experience here; success has almost universally attended their application of telescoping crowns to removable bridgework. However, the addition of the tube and split-post unquestionably affords additional security for the bridge, which it may be well, in some instances, at least, to utilize. In adopting this plan, the pulp is removed and the canals filled. The crown is then prepared as indicated for the shell crown, and the band fitted with its diameter at the cervical border very slightly larger than at the occlusal end. The line of the crown is marked on the inner surface of the band and the tube prepared and fitted to one of the canals and later attached to the floor, which is added to the band and finished, according to the method discussed for anterior abutments. The proper precaution of securing the tube in a parallel position with the sides of the band must be observed. When this stage

[1] "Principles of Bridgework."

of construction has been reached it is advised[1] to coat the inner surface of the band slightly with wax and fill with a fusible metal. The outer band is then prepared by cutting the band slightly short, attaching the two ends, and drawing it down over the inner cap, reinforced with the fusible alloy until it extends just to the gum line. The writers prefer to make these attachments directly to the natural tooth, for the reason that time may be conserved with an equal accuracy in the adjustment. The band is then cut flush with the inner cap and the floor attached to it. The attachment of the cusps and the split pin may now follow according to methods previously described.

Inlay Attachment.—While at the present time the tendency would be to utilize the casting process in constructing the inlay, as here considered, no special advantage is derived in adopting this method of construction, and the former means of burnishing gold plate to conform to the cavity is equally efficient with a saving of time in securing the final result. The method is as follows: The pulp is devitalized and the canals treated according to any of the methods generally adopted for this procedure. In opening the tooth for the treatment of the canals, consideration should be given to the form of the cavity for the inlay, that an unnecessary destruction of tooth structure may be avoided. But in all cases the treatment of the canals must be efficiently performed if permanent results are to be obtained. Having obtained the cavity outlines, a piece of 36 gauge 24-k. gold is annealed and gently swaged to the cavity form. This is then perforated, that the tube, which has been previously formed to admit of a 14 gauge post, may be passed through the plate into the floor of the pulp chamber.

[1] "Principles of Bridgework."

The relation of the tube to the plate is secured with wax, removed, invested, and soldered. The inlay is then built out to the desired form by flowing 22-k. gold solder over its surface, care being taken not to distort the adaptation of the inlay, and to prevent the solder from flowing upon its inner surface (see chapter on Inlays). The inlay with the platinum tube extending through it being completed, a groove is cut into it from the tube to its mesial end sufficiently deep to admit the post, which later is to be attached to the dummy, and extended into the tube, without having it protrude beyond the occlusal surface. The post is constructed by bending half-round iridio-platinum wire until the flattened surfaces come together and closing the end with solder to within a short distance of the bend. It is then filed and fitted to the tube and groove; the split portion is later to be slightly opened for the "spring," which will firmly hold it in position. The inlay with the post in position is returned to the tooth, the bite and impression secured, and the model prepared. A replaceable tooth is then selected, ground to meet the indication, casting wax adapted to its base, returned to the model, the wax trimmed as desired, and the casting made as previously discussed. Later the post is attached to the cast base with wax, invested and soldered. The margins of the cavity for the inlay must extend buccally and lingually beyond the dummy and beneath the gum margin, so as to be within the immune areas of the tooth. The sulci upon the occlusal surface must also be included in the cavity form. Fig. 274 illustrates the method.

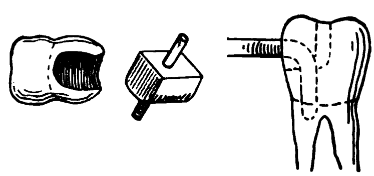


FIG. 274.

Telescoping Crowns.—In the inferior arch with the

molars on both sides missing, the anterior teeth in position, including the first, or both bicuspids, no method of construction, all factors considered, which includes the general convenience of the patient, both in adjusting and removing the appliance, the simplicity of construction when compared to other methods, and its efficiency, equals the principle of telescoping crowns in its application to removable appliances with the lingual bar attachment for supporting the two saddles. While the application of this principle may be extended to other locations, it is especially efficacious when applied to the condition previously designated and may be suggested with emphatic assurance of success. When the second bicuspids are missing and the adjustment must be made to the first bicuspids, the esthetic factor should be considered, and if the presence of the gold crown in this location is contraindicated, other means of construction must be adopted. But this is rarely necessary, as the inferior teeth are quite well hidden from view by the lip.

In preparing the abutment teeth it must be decided whether devitalization is necessary as the first stage of the operation. In most instances an affirmative decision will be reached. This is the rule of practice, not only when telescoping crowns are to be constructed, but in the adjustment of the single shell crown as well, for reasons now well understood and which have been previously noted. While this is now accepted as the rule of practice it is not invariable, and while its deviations are less frequent when the teeth must be ground for telescoping crowns than in cases which require but the adjustment of the crown, these nevertheless may occur; in fact, under certain conditions they are positively indicated, and may be practiced according to the writers' experience with accruing advantages to both patient and op-

erator. The writers have seen many cases of failures in bridgework owing to septic involvement of the apex of the root following devitalization, even though very careful attention was paid to the subsequent treatment of the canals. This might have been avoided if devitalization had not been practiced. (For information the reader is referred to chapters wherein these matters will be found discussed.) It must be understood that the intention here is not to recommend pulp conservation when a shell crown is to be adjusted to the tooth; the indicated procedure, no doubt, in most instances, is to remove the pulp. The present argument is more a plea for a higher regard for the vital relations of the tooth, which frequently are abused and owing to which many disastrous results have been recorded, and will be recorded in the future in the practice of those who make every consideration subservient to the *mechanical perfection* of the completed work and in consequence may be induced to make unnecessary sacrifices.

Procedure.—The abutment teeth are prepared as previously indicated, and prior to the fitting of the band it should be observed that sufficient space exists between the abutment and adjoining tooth to accommodate the telescoping crown, and that the occlusal surface has been sufficiently reduced to accommodate the cusps to be later attached. Parallelism between the abutment teeth must also be enforced. When these requirements have been satisfactorily established the band is fitted to the tooth, its ends joined by sweating or with a small piece of 22-k. solder, the cervical portion trimmed to conform to the gum festoon and made flush with occlusal edge. The cap is then adjusted to the band and the piece finished, polished, and cemented to the tooth. The abutment tooth on the other side is similarly treated. Later the tele-

scoping crowns are completed with the requirements of occlusion and contact desirably established. As previously stated, the telescoping crowns should preferably be adjusted upon the natural teeth. Better results are likely to be obtained if this plan of procedure is followed.

When the impression has been taken with the removable crowns in position a thin layer of wax is flowed in their interior and the model poured. The crowns may easily be removed from the model by moderately heating. Pure gold, about 36 gauge, is next annealed and made to conform as a saddle to the portion of the model where the artificial substitutes are to be placed. When a satisfactory adjustment has been obtained, a little sol-

FIG. 275.—SHOWING LINGUAL BAR, ALSO ROACH ATTACHMENT.

der is flowed over the gold plate to reinforce it. The presence of the solder also secures the casting which later is made directly against the saddles. The lingual bar is next adapted to the soft tissue, and to the saddles, as shown in Fig. 275, and the relation of the crowns, saddles, and bar sustained with wax, invested and sol-

dered, using but a minute quantity of solder, as, later, the saddles have to be detached that the castings for the replaceable teeth may be made to them. When the foregoing parts have been united with solder the piece is cleansed and adjusted to the natural teeth. If the adjustment is satisfactory an impression and bite are taken and the model poured. Suitable replaceable teeth are selected and ground to the requirements of the case. The casting wax is then adapted to the crowns and these are returned in their proper position upon the model and secured in position upon the saddles with the wax previously placed there. The wax is trimmed to the desired form, the saddles detached from the crowns and lingual bar, the porcelain crowns encased in the casting wax, returned to the saddles, and, if the adaptation is as desired, the porcelain crowns are carefully removed from the wax, the remaining part invested, and the casting made as previously indicated. When the casting has been removed from the investment it is thoroughly cleansed and finished up to the final polishing. The porcelain crowns are then temporarily placed in their position and the saddle returned to the model, the shell crowns and lingual bar adjusted to place, and the correct adjustment of the parts sustained with wax. The porcelain crowns are removed and the remaining pieces again assembled with solder and the case completed as previously discussed.

The telescoping crown principle is also applicable where teeth have been lost only on one side. Fig. 276 illustrates a case from practice. The second molar and first bicuspid are in position, the intervening teeth, as well as the cuspid, have been lost. The missing teeth are all replaced, utilizing the telescoping crown principle, the saddle, and the replaceable tooth form with cast base.

The two abutments which support the appliance were considered adequate, as the "bite" is not a strong one. This appliance has been, at this writing, in service for almost three years with the abutment teeth apparently in as good a condition as when the appliance was first adjusted.

Fig. 276.

Fig. 277 illustrates another case from practice very similar to the preceding. The second molar and first bicuspid are in position. The molar, second bicuspid, and cuspid are missing. The lost teeth were replaced after the method previously discussed. Figs. 278, 279, 280 illustrate other cases.

Fig. 277.

Fig. 278.

In those cases in which several teeth have been lost upon one side and no posterior abutment is available upon the side of the missing teeth, the same general plan of construction may be followed, utilizing a molar upon the opposite side as an abutment for which a telescoping crown may be constructed to which the lingual bar is attached. Or a shell crown, with one of the patented devices for removable bridgework, preferably the "Roach," presently to be described, may be attached to the molar crown, which is cemented in position, the

other part of the device being attached to the end of the lingual bar. Fig. 275 illustrates the application of this method of restoration.

Fig. 279.

Patented and Procurable Attachments for Removable Bridgework.—These special attachments were introduced to afford a ready means of securing the removable

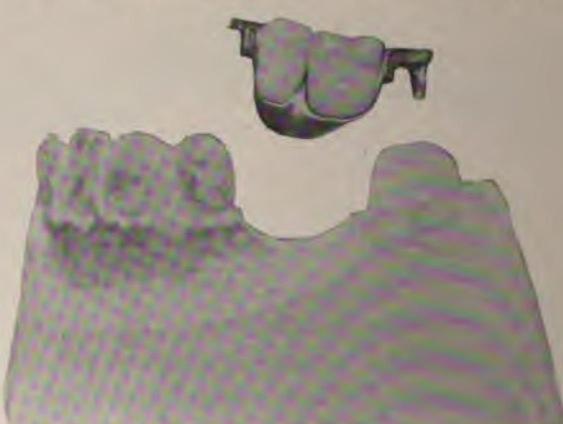


Fig. 280.

principle in bridgework, and sufficient retentive stability for practical application, and as these attachments are

specially constructed, therefore accurately adjusted, and procurable from the manufacturer, they may be advantageously utilized in many instances. But it must be recognized that they are not of universal application; that in many cases they are unable to resist for any length of time the applied stress; that there is loss of the retentive stability through friction between the two interacting parts of the attachment, which when it occurs cannot be readily corrected; and, that a high degree of skill is necessary for the exact parallelism which must be obtained when two attachments are utilized upon one bridge piece. The successful utilization of any of these devices depends upon the judgment displayed in the selection of the attachment, and in the correct appreciation of the conditions to which the application is to be made.

THE "ROACH" ATTACHMENT.—The device introduced by Dr. F. E. Roach has received quite a general endorsement, and is regarded as the best of the methods suggested for effecting the removable principle in bridgework.

The Roach attachment consists of two parts (Fig. 281), the slotted round tube constructed of 26-gauge clasp metal, and the ball and projecting stem. The projecting stem has a shoulder near the ball which sets against the slotted portion of the tube, while the end of the stem is provided with a large head that secure anchorage may easily be made when the device is utilized in vulcanite work.

When applied to bridgework the procedure is as follows: Having the shell crown, or any other form of abutment piece, in position, a wax bite and plaster impression are taken with the abutment pieces in position. Prior to forming the model a thin layer of wax may be flowed into the interior of the crowns. The crowns are

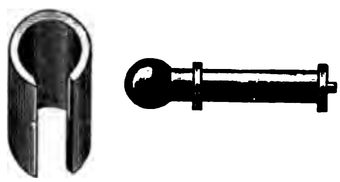


FIG. 281.

removed from the model, the wax from their interior removed, after which they are replaced upon the model and the tube portion of the device is waxed in position. The crown with the tube portion of the attachment waxed in position is then removed from the model and the retention in position made permanent by means of solder. A saddle may now be constructed for each side according to the method previously indicated, and when its adaptation to the model with the crowns in position is as desired, the ball portion of the device is adjusted to its proper position upon the saddle, and secured with wax. The saddle with the second part of the device attached to it is removed from the model, invested and soldered. When this step of the procedure has been satisfactorily attained, the saddles are replaced upon the model and the lingual bar fitted and attached to them, as outlined in the consideration of bridgework. The abutment crowns with one portion of the Roach attachment soldered in position, and the saddles now united by the lingual bar, with the second portion of the attachment soldered in place, are now adjusted to position in the mouth and a bite and impression taken. The case is then completed after the manner previously discussed.

In some instances the two parts constituting the "Roach attachment" may be reversely applied, i. e., the ball and stem portion may be *directly cemented to the tooth* or attached to the abutment piece, and the tube portion attached to the appliance. This plan may be followed where the cuspid teeth are utilized as the abutments Where the ball and stem portion is directly attached to the tooth, a hole is drilled into the tooth to

exactly accommodate the stem part of the device with a drill provided for this purpose, and the opening of the hole enlarged to receive the shoulder upon the stem, that a smooth relation may be obtained.

The shoulder upon the end of the stem should be ground off and the stem ground flat and roughened to prevent loosening. (Fig. 282.) The tube will have to be attached to the appliance in these cases by means of projecting wire or plate.

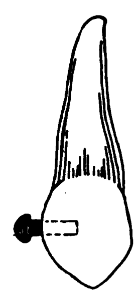


Fig. 282.

The superiority of the "Roach attachment" is so clearly evident as to render useless the consideration of the many devices that have been introduced for a similar purpose. But as several of these have been successfully applied, and for the sake of completeness, a short description may not be out of place.

The Condit Attachment.—This device consists of a slotted gold clasp tube (a) open at both ends which is to be soldered to the abutment crown. A telescoping tube called the shield (b), open at one side and end, contains a round pointed pin (c) which projects from the center of the closed end, also a V-shaped metal projection (d) attached to the side opposite the opening for the purpose of securing attachment to vulcanite appliances, but is not used in metal work. The pin of the telescoping tube passes into the smaller tube (a) and is firmly held by the latter. It will be observed that the surface contact between the two parts of the device is much greater here than in the Roach attachment, allowing practically no play, and when two attachments are utilized for one appliance perfect parallelism must be secured. Fig. 283 illustrates the device and its utilization in special cases.

THE GRISWOLD ATTACHMENT.—The so-called "Griswold System," which has been emphatically praised in many quarters for its practical and quite general application, consists of three types of anchorage known as the "spring studs," "U" spring, and the "V" attachment. Of these the two former have been found to be entirely unsatisfactory, and are now discarded, the "V" at-

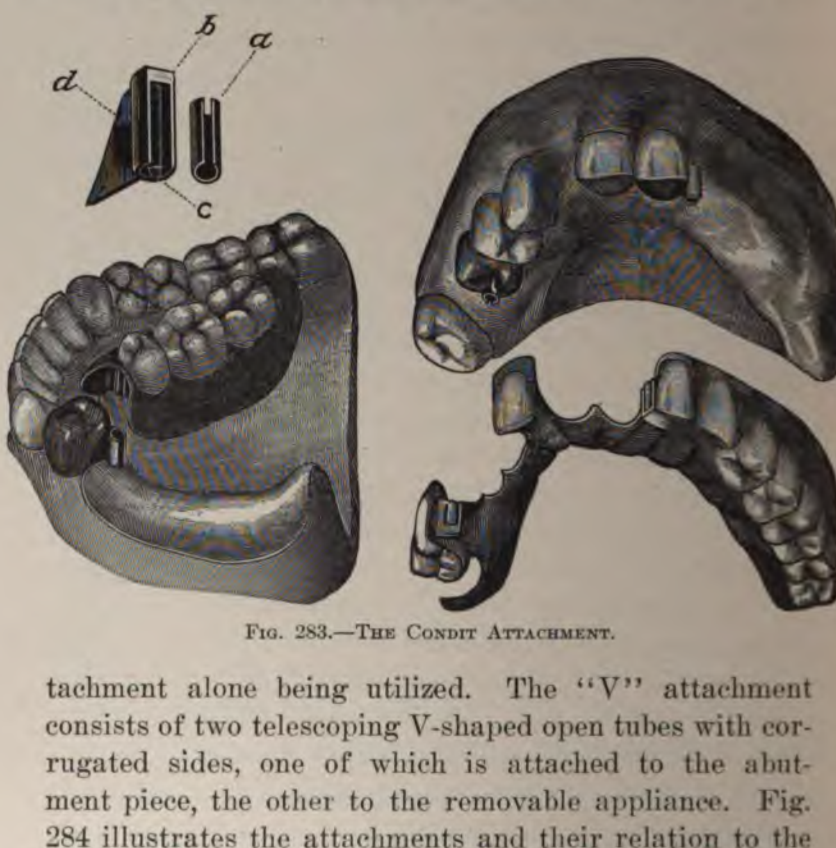


FIG. 283.—THE CONDIT ATTACHMENT.

tachment alone being utilized. The "V" attachment consists of two telescoping V-shaped open tubes with corrugated sides, one of which is attached to the abutment piece, the other to the removable appliance. Fig. 284 illustrates the attachments and their relation to the abutment pieces.

Connected Abutments.—In discussing the mechanical principles underlying the application of bridgework it was noted that, in utilizing two or more natural teeth to

support an appliance to which missing teeth were attached, the abutment teeth were subjected to an additional strain, and that, when the construction of the piece in this regard was well planned, no untoward results followed; pathological conditions, however, might be induced if the abutment teeth were made to bear an excessive strain, or if their retentive structures were already impaired the strain, which under normal conditions would in no manner impair the integrity of the

FIG. 284.—THE GRISWOLD ATTACHMENT.

abutment teeth, might easily end in disaster when applied to impaired teeth, if no provisions were made to assist such teeth. This assistance is rendered by connecting the loosened abutment roots before adjusting the bridge, and when this is done even impaired abutment roots may render service for a number of years.

Dr. Fossume's Method.—Dr. F. L. Fossume has suggested several methods of uniting abutment teeth, equally applicable to loosened or normal teeth. The abutment teeth are provided with abutment pieces according to indications, and the abutment pieces are united by means of a heavy piece of square iridio-platinum wire. This is adjusted to the natural teeth, cemented in position, and an impression taken. A gold or platinum saddle is swaged to fit over the bar and against the gum tissue. Telescoping crowns, clasps, or any other device having

been previously constructed to which the saddle is attached, and later the missing teeth, are added to the saddle.

Fig. 285 is a model with the appliance uniting the cuspids, and above it is the removable piece with the missing incisors in position. In this case the pulps are to be removed from the cuspids, the canals treated and filled, and fitted with iridio-platinum posts. Gold plate 24-k. 36 gauge is next adapted to the lingual surfaces of the cuspids and iridio-platinum posts pressed through the gold plate into their position in the canals, and attached to the gold plate with hard wax. Each post is separately united to the plate with solder, and the gold plate reinforced. These are returned to their position upon the natural teeth and adapted as desired. An impression is next taken, the abutment pieces withdrawn, and upon the model the connecting bar fitted and soldered to position. When this has been satisfactorily attained, the united pieces are again placed in position, an impression taken, and the connecting bar fitted and attached to the abutment pieces. Later the

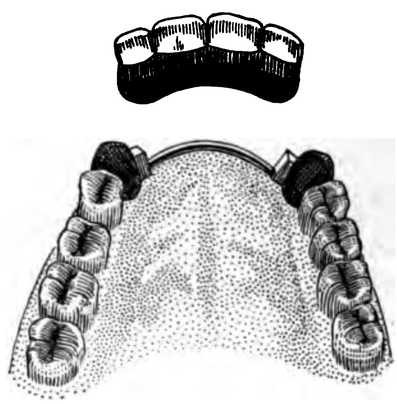


Fig. 285.

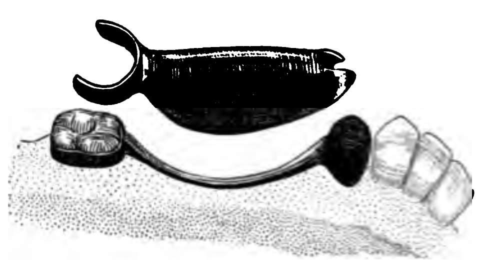


Fig. 286.

missing teeth are added to the saddle, as previously stated.

Fig. 286 illustrates a case for the posterior part of the mouth, the saddles being supplied with clasps fitted to the abutment pieces.

The principle of the bar attachment is also applicable in those cases where the posterior abutment is absent. Fig. 287 is similar to the preceding illustration excepting the absence of the posterior abutment. For this case a shell crown is adapted to the bicuspid tooth, to which is soldered the iridio-platinum bar extending beyond the tooth along the ridge for about the distance of the next tooth; at the end of the bar a crossbar is soldered to form a T, as shown in the accompanying illustration. The cuspids are prepared for a plate and post attachment. The saddle is then swaged to engage the bar, and a suitable clasp fitted to the gold crown is next soldered to the saddle. The cuspid root is provided with a cap and tube, and the "split post" and porcelain tooth are attached to the saddle. The missing teeth are then attached to the saddle after any of the methods previously discussed.

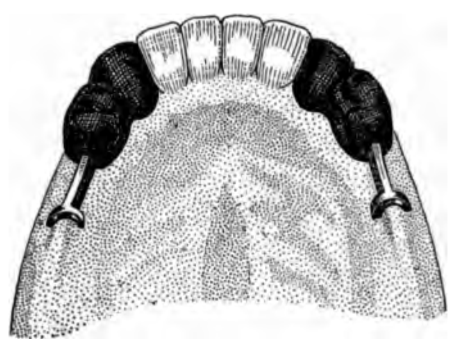


Fig. 287.

Porcelain Bridgework.—The esthetic possibilities realizable through the application of porcelain in dental bridge construction has always been the magnet for the creative ingenuity of those endeavoring to reach the highest standards in replacing lost teeth, and, although

this field of dental effort has not reached the state of general practical application to be observed in other directions, it nevertheless is not entirely wanting in usefulness when its utilization is based upon a sound appreciation of all the related factors. The inherent defect of porcelain is its *brittleness,* and in bridge construction this, in a measure, can be compensated for if the conditions allow of the use of a sufficient bulk of material. Hence the essential prerequisites for its employment are associated with the factors of location, resorption, and occlusion. In other words, if the esthetic demands of the case are of paramount importance, and if a sufficient bulk of material can be utilized, a porcelain bridge may be constructed. The recent advancements, however, in dental bridge construction made possible with the introduction of the replaceable tooth and the casting process may seriously question the advisability of constructing a porcelain bridge at any time. Modern bridgework has reached a high state in the esthetic requirements of replacing lost teeth, and, while perhaps not quite as effective in this regard as the porcelain bridge may be made to be in some instances, generally it should be preferred as a method of substitution, because of its greater stability and the far greater convenience in making repairs. When these two factors are viewed in the importance to which they are justly entitled, aside from the simplicity of technique which obtains in the present general method of bridge construction in comparison to that of the all porcelain bridge, as previously stated, it may seriously be questioned if this method of replacement should be adopted at any time. But a case may present where the *highest esthetic possibilities* are of such paramount importance that all other considerations are subordinated; therefore,

a consideration of the technique of porcelain bridge construction may prove useful.

Procedure.—The abutment roots are prepared in the usual manner, and the band prepared from platinum 28 gauge. The ends of the band should be *lapped* and united with platinum solder. This prevents the opening of the joint in the fusing of the porcelain, which is likely to occur if these precautions are not taken. The floor and post are then added to the band, the floor being prepared from 32 gauge platinum, and the post from the usual 14-16 gauge iridio-platinum wire. With the caps in their proper position, the bite and impression are taken, and prior to pouring the model melted wax should be flowed into the interior of the cap and upon the surface of the post, to facilitate subsequent removal from the model. After the model has been poured and separated from the impression, and with the wax bite in position, both are adjusted upon the articulator; later suitable facings are selected and ground to the requirements of the case. As platinum is not a rigid metal, the facing to be adapted to the cap should be ground so that it may overlap the labial portion of the band and support it in this region. A second precaution to be observed in grinding the facings is that they should not be in actual contact with each other, in order that space may exist to accommodate their expansion during the soldering process, avoiding their fracture. When the facings have been ground to meet all the requirements, the caps are removed from the model by moderately heating, the wax from their interior burnt out, after which they may be replaced upon the model, and, if they, as well as the facings, are in satisfactory position, the relation is secured with hard wax, the piece removed from the model and invested. The in-

vestment should be strong enough to resist the force later applied in bending the pins to the connecting bar prior to the soldering.

When the investment has set the lingual surfaces of the facings are cleared of all investment material, excepting a slight overhanging portion at the cervical and incisal region, which is necessary to prevent their displacement during the soldering process. Iridio-platinum wire of about 16 gauge is next adjusted to the facings, so that when the pins are bent over they will be in contact with the connecting bar, and the attachment with solder may be made. If no saddle is used, which is the plan of construction under present consideration, it is best not to have the connecting bar in direct contact with the facings, for the reason that a stronger porcelain addition may be made. Small pieces of investment compound may be placed upon the facings to prevent the bar coming in actual contact with the porcelain. Fig. 288 shows the relation of the bar to the facing. If the bar is placed in direct contact with the facing, and the porcelain added as indicated by the dotted line, the weakness of the finished piece is evident, the thin section of porcelain above the bar easily breaking away even under moderate stress.

Fig. 288.

When the bar and pins of the facings have been satisfactorily adjusted, the case is slowly heated and soldered with platinum solder. When this step of the procedure has been completed, the case is allowed to cool, after which the united facings are removed from the investment placed in the acid bath for a sufficient length of time to remove all foreign matter, and the piece further finished by means of stones and disks for the addition of the porcelain. Suitable body is selected, mixed with

distilled water, and applied in a manner to conform to all the indications, and the case completed after the manner discussed in the consideration of the porcelain inlay. When completed all the metal excepting a portion of the band is covered with porcelain, and ideally meets the esthetic demands of the case.

In those cases where a molar is used as the posterior abutment and it is considered advisable to utilize the telescope crown, this obviously must be constructed of platinum. The band should be constructed of 28 gauge platinum plate, and the cusps when attached should be reinforced with platinum solder. In adjusting the lingual bar to the facings, provision should be made that its flattened end may extend across the lingual surface of the molar crown for some distance, thereby obtaining the maximum strength for the piece when the attachment is completed with solder.

If serious objections are made by the patient to the color of platinum, the case may be constructed by forming a cap of platinum for the molar, and when the porcelain has been added a gold shell crown may be formed and soldered to the platinum cap, also to the piece of platinum which has been extended upon the approximating portion of the adjacent tooth.

CHAPTER XXXIV

CAST DENTURES OF ALUMINUM AND FUSIBLE ALLOYS

The great changes brought about by the casting method in the general technique of crown and bridgework have also extended to the construction of dentures of aluminum and fusible alloys, and the perfection of the casting method is as noticeable in the results obtained in the type of construction here under consideration, as it is in relation to crown and bridge construction. It has long been realized that the most desirable adaptation is secured when the base of the denture is made to conform directly to the cast, which in metal dentures involves the principle of casting.

ALUMINUM

The many valuable qualities possessed by aluminum. its inoxidability, low fusing point (1,300° F.), malleability, and ductility, its unchanging color in the mouth, and especially its lightness (S. G. 2.56), have particularly commended it as a metallic base for dentures, but the swaged aluminum plate does not meet the requirements of a satisfactory denture, which fact was soon learned after its attempted utilization. Hence, many efforts have been made to conform the molten metal directly to the cast by the different methods introduced from time to time; but, as these are more or less imperfect in the results obtained and also require the use of an apparatus quite complicated, in comparison to the pres-

ent method, the principle of construction did not enlist the favor of many practitioners until the present time.

The first attempt to cast aluminum was made by Dr. J. B. Bean of Baltimore nearly fifty years ago. Dr. Bean utilized a column several inches high which was filled with the molten metal, and, notwithstanding its lightness, the weight of the column of metal in some cases forced the lower part to an accurate reproduction of the mold.

Later Dr. C. C. Carroll of Meadville, Pa., devised a method for casting aluminum under pressure, and claimed that by alloying it to control shrinkage it could be cast directly to the teeth. For upper dentures he recommended the following formula:

Aluminum	98 per cent.
Platinum	
Silver	2 per cent.
Copper	

The fusing point and specific gravity of the alloy closely resemble those of aluminum.

For lower dentures he recommended an alloy of aluminum, tin, copper, and silver, the fusing point of which is about 700° F., and the specific gravity 7.5.

The alloy intended for upper dentures must be cast under pressure. That intended for lower dentures may be cast without pressure. The pressure was obtained by a blast of air conveyed through a rubber tube by compressing a bulb, the tubing being attached to the cup containing the molten aluminum. Fig. 289 illustrates the Carroll apparatus.

Following the Carroll apparatus, Dr. Zellar introduced his device for casting aluminum, which differed

from the Carroll apparatus in having the crucible and flask permanently attached. The furnace is also arranged in two parts. The lower portion is utilized for heating the flask and investment, the upper for melting the metal. Atmospheric pressure is utilized for forcing the molten metal into the mold.

FIG. 289.—DR. CARROLL'S FLASK AND HEATING APPARATUS. ("American Textbook of Prosthetic Dentistry.")

Despite the enthusiasm of the inventors of these apparatuses, the practice they advocated was espoused by but a few, as the process was somewhat involved, and the final result too uncertain. More recently Dr. R. C. Brophy introduced his method of jarring the aluminum into the mold for which greater simplicity is claimed, with an increased rate of successful results.

Dr. Brophy describes his method as follows:

"In my alloy I use 5 per cent. of silver. My method of introducing the metal into the matrix is extremely simple. After the case has become thoroughly dried out and heated, which is evidenced by the flask becoming red hot, I place the ingot of metal in the crucible, which is attached to the flask, similar to Carroll's (Fig. 289), and hold until the metal fuses. With tongs I lift the flask from the furnace and sharply jar or jolt it on the bench. This jolting I find to be all that is necessary to inject the metal into the matrix. If the case is thoroughly dried and heated the casts will be perfect nine

times out of ten." Fig. 290 illustrates Brophy's apparatus.

Not until the simplicity and effectiveness of the casting method, as practiced to-day in relation to inlays, crown and bridgework, began to be generally realized was the attempt made to utilize a similar process in the casting of aluminum plates, the metal being forced into the mold either by centrifugal force, by atmospheric pressure following the exhaustion of air from the mold,

Fig. 290.

Brophy's Flask and Crucible. Brophy's Gasoline Heating Apparatus for Drying the Case and Melting the Metal. ("American Textbook of Prosthetic Dentistry.")

or by compressed air, similar to the methods adopted for constructing inlays, or the different parts for crown and bridgework.

Dr. Robert Seymour of Philadelphia has introduced a method for casting aluminum dentures which has been very favorably received, and whereby uniformly successful results have been obtained. Dr. Seymour utilizes a simple casting device fitted with a plunger cap which is packed with moist asbestos fiber and brought in contact with the flask. Another favorable feature of Dr. Seymour's method is the opening of the flask after being heated, and the removal of all the softened wax excepting that remaining in the gateways and sprue.

The open flask makes it easy to remove the wax and to completely combust all the remaining wax, which otherwise would be likely to interfere with the formation of an exact casting. The fact that this could not be done as advantageously in the previously mentioned methods may account for the failures unexpectedly encountered, similar to the failures of inlays, when prepared without first completely combusting the wax model. Dr. Seymour describes his method as follows:

"A plaster impression is taken of the case in the usual manner, and if a vacuum chamber or relief is needed it is cut in the impression. This is then given a thin coat of equal parts shellac and sandrach and when thoroughly dry an additional coat of sandrach varnish. When quite dry a model of silex and plaster in the proportion of three of the former and one of the latter is made, always taking the precaution to thoroughly soak the impression in water before running the model (Fig. 291).

Fig. 291.

"The silex I use for this purpose is a slightly coarser grade than that used for inlay investment. This will give a harder model and still produce a smooth surface on the casting. The plate is now waxed in the usual way, using tennax wax, as it is thinner than the ordinary base plate.

"The following additions will be noted in Fig. No. 292:

"(a) Plate spurred or scored.

"(b) Wax rim inside and out.

"(c) Gateways.

"(d) Sprue.

"The sprue may be a No. 10 wire, as shown in the

FIG. 292.

illustration, but we prefer a short wax sprue, as shown in the next illustration (Fig. 293).

"The plate being ready to invest, it is wise to place it in water and allow it to absorb all it will take up. The case is now invested in the lower half the same as an ordinary rubber case, bringing the investment to the edge of the wax. When this is properly trimmed place a V-

shaped groove encircling the model a short distance from the wax. This surface is now given a slight coat with oil afterward brushed lightly over with powdered soapstone; where the rugæ surface has been transferred by means of tin foil, as in the case shown, this tin should also be slightly oiled.

FIG. 293.

"The second half of the flask is now placed in position filled with investment, taking the precaution to shake it well to place; while this is still soft a recess is cut away in the central opening of the flask, until the short wax sprue is exposed; this forms a crucible for the subsequent melting of the metal. After the investment has become hard the flask is subjected to dry heat for a few moments and separated; the entire base plate of wax is readily removed, and the only portion of wax left to be burned out is that contained in the gateways and sprue. The case is now heated on the furnace, and if any carbon is left on the surface of the model it can be readily removed with the blow pipe, as the entire surface is exposed and has a great advantage over the closed flask method, as it is difficult to burn out such a large quantity of wax; and if this is not done the resulting cast is a failure. This is true in both systems of casting, where pressure is placed directly against the molten metal, or where the method of creating a vacuum is used.

"When the case is hot, the upper part of the flask is again placed in position, and it will locate itself by means of the V-shaped depression which was cut in the

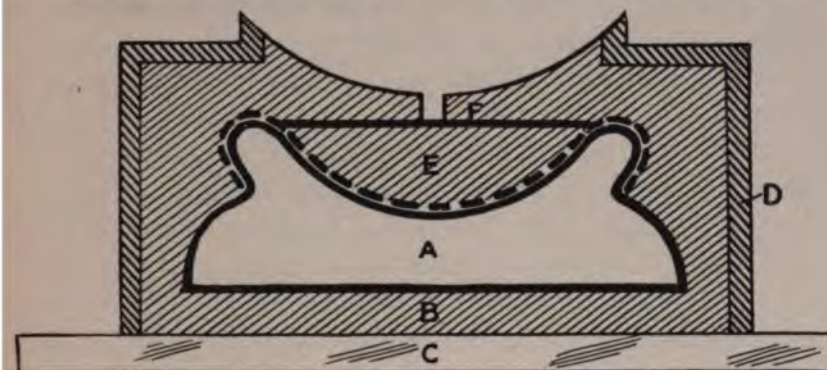


Fig. 294.

first half, as the second half of the flask will have its counterpart. It also forms a guard to prevent escape of the metal from the flask.

"Fig. 294 shows a crossed section of case at this stage. The cup is now placed on the base of the machine and the plunger cap placed firmly against it for the permanent adjustment of the flask. The metal is now heated in the recess prepared for it, and when thoroughly melted the casting is made by packing moist asbestos fiber in the plunger cap of

Fig. 295.

the machine and bringing it gently but firmly against the flask. When the metal is cold, remove and cut away the

gateways, leaving a small portion remaining to help retain the rubber. The teeth are placed by means of the rubber attachment.

"The advantages of this method over the swaged plate are as follows:

"1. Better adaptation, especially in undercut cases, as the case is cast direct on the original model.

"2. It is stronger, as a rim is carried not only on the outside edge of the plate, but also on the lingual surface a short distance from the teeth; the plate can also be varied in thickness according to the strain.

"3. Better anchorage for the teeth."

The above method affords a satisfactory and simple means of casting aluminum, superior to the results obtainable by previous methods. As commercial aluminum is supplied in purer form, eliminating its contamination by iron and other metals, so will the deterioration commonly noticed when the impure product was formed into plates and placed in the mouth be a thing of the past, and with the effective means at our command, made so with the advent of the casting process, for casting the metal to the form of the mold, this type of denture is likely to find increasing favor with many practitioners.

FUSIBLE ALLOYS

In the use of the term "fusible alloy" reference is usually made to such alloys as Watt's, Weston's, Moffat's, etc., which are proprietary preparations; hence their composition is not definitely known; or to the following alloys, the formulæ for which have been given to the profession:

Kingsley's Alloy—Tin, 16 ounces; bismuth, 1 ounce.

Reese's Alloy—Tin, 20 parts; gold, 1 part; silver, 2 parts.

Bean's Alloy—Tin, 95 parts; silver, 5 parts.

These alloys are mostly utilized in cases of full lower dentures, where weight is the desirable quality of the denture, and which cannot be obtained in the use of aluminum.

For upper dentures the fusible alloys are too heavy; therefore, never advantageously utilized.

In constructing a fusible alloy denture the impression is taken in the ordinary manner, and the cast prepared from an investment compound. About equal parts of plaster and sand may be used as the compound for forming the cast, or marble dust, asbestos, and other substances may be substituted for the sand. Whiting is preferred by some, as it gives a smoother surface to the cast.

The base plate and bite are prepared as previously indicated, and when satisfactorily arranged upon the articulator the teeth are selected and placed in their proper positions. As the alloy which takes the place of the base plate is much heavier than vulcanite, but the thinnest layer of wax or modeling compound is formed into the base plate, and the least quantity of wax is used to attach the teeth to the base plate consistent with the requirements of the case.

The trial plate and teeth arranged upon it may now be tried in the mouth, and if found to be satisfactory the case is returned to the cast and secured in position by melting the wax along the alveolar border with a hot spatula.

The flasks (Figs. 296, 297) into which the molten metal is poured are formed so that a column of metal will force that first poured into all parts of the mold.

The weight of the alloy easily accomplishes this. The procedure is as follows:

The lower portion of the flask is placed upon a piece of smooth glass, and the cast placed therein. The investment compound, a similar preparation to that used in constructing the cast, is mixed, and the cast invested. When set the investment is trimmed so that the mold will part at the upper border of the base plate.

FIG. 296.—WESTON'S FLASK.

For the Watt flask the pouring and vent gates are prepared as shown in Fig. 298.

The investment in the lower half of the flask is coated with a thin mixture of whiting, and when dry a thin layer of shellac varnish is applied. This prevents adhesion of the investing material of the other half of the flask. This is now carefully filled with the investment material after being adjusted to position, and the upper surface made smooth. When the material has hardened the

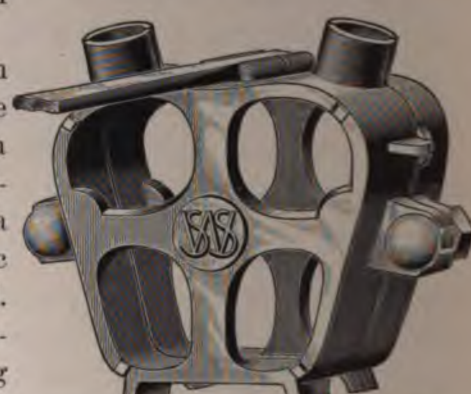


FIG. 297.—WATT'S FLASK AND WRENCH.

flask is warmed, the two halves separated, and the wax removed. Boiling water should be poured into the mold to remove particles of wax adhering to the pins, or that may remain in other portions of the mold. The position of the gates in the upper half of the flask being clearly indicated by the ridges formed by the investing material running into the lower gates, the ridges are trimmed down, and the gates cut in the upper portion of the flask to correspond to those previously formed in the lower portion.

FIG. 298.—GATES IN WATT'S FLASK.

When the wax has been thoroughly removed, and the gates prepared as indicated, the two halves of the flask are fastened together, and the joint between them carefully closed with investment material to prevent escape of the alloy. The investment material is next thoroughly dried out by subjecting it to a low heat, and when all the moisture is removed the case is ready for the pouring of the alloy.

The metal is placed in an iron ladle, and as soon as it is melted it is poured into the mold while the latter is still hot. The nearer the temperature of the mold is to the melting point of the alloy the finer will be the cast.[1]

[1] "American Textbook of Prosthetic Dentistry."

When the flask has cooled it is opened and the casting removed. The surplus portion is sawed off, and the denture smoothed down with files and sand paper, and polished first with powdered pumice and then with chalk. If the base plate and the wax uniting the teeth to the base plate have been made perfectly smooth, considerable time may be saved in the final polishing process.

Repairs can be made in this type of denture by preparing a dovetail space for the pins, fitting, and waxing the tooth in position. The case is then invested in the flask, the wax portion alone remaining uncovered. The gate is cut leading to the wax, and the flasking and subsequent steps followed as indicated.

Cast dentures of fusible alloys may also be prepared with vulcanite attachment, but as this type of denture is not generally recognized as an acceptable method of replacing the natural teeth, and furthermore, as the present casting method appears to have materially improved the "status" of the cast aluminum plate, it is questionable whether the fusible alloy denture with rubber attachment should ever be constructed.

CHAPTER XXXV

CONTINUOUS GUM DENTURES

The earliest attempts at restorations by attaching artificial teeth to a metallic base by means of a fused enamel composition are recorded in France. These efforts, however, resulted in failure, largely because of the imperfect means at the command of these investigators for fusing the compositions which they utilized, also because of their deficient knowledge concerning the composition of porcelain compounds.

The profession is indebted to the labors of Dr. John Allen of New York City, who in 1846 placed this method of construction upon a successful basis. A few years later, in 1851, Dr. Allen was granted patent rights for his invention, and five years later he again received patents, the first issue having been returned, for a perfected method of construction.

Continuous gum work never attained a wide popularity among practitioners, partly due to the complex character of the process of construction with more or less uncertainty in the final result, and in part to its expensiveness, which but few patients are willing to meet.

The earnest and persistent efforts of a few enthusiasts, together with the ideal means furnished in the electric furnace for fusing the porcelain compound, and the improved porcelain compositions supplied by the dental depots, have eliminated much of the uncertainty attend-

ing the earlier efforts, and at the present day this method of restoration affords the very highest possibilities in esthetic and hygienic requirements, with satisfactory permanency if the denture is cautiously handled.

The objections which have been so long sustained against continuous gum work, especially in regard to the great weight of the finished piece, and to the uncertainties attending the baking process, have been materially reduced, especially in regard to the latter, owing to the perfection of the electric furnace and porcelain compounds, as previously stated. And while the former objection, viz., the excessive weight of the finished denture, has also been reduced, it is still a factor, in many cases contraindicating its use. Dr. D. O. M. Le Cron[1] states that for a number of years he has obtained most satisfactory results in the use of Nos. 32 to 36 gauge plate, and in the use of the lighter gauge metal the weight of the denture is considerably lessened.

The combination of porcelain and platinum is preeminently hygienic, being unaffected by the oral secretions or the products of fermentation and putrefaction. It may be made absolutely clean, and retained in a polished state, by simple cleansing methods adopted by the patient, and, as has been previously noted, the artistic effects possible with this type of denture surpass those of any other method of restoration.

Preliminary Steps.—These include the taking of the impression, the preparation of the cast, marking the outline form of the denture, forming the dies and counterdies, etc., according to the methods discussed in the preceding chapters. Especial attention should be given the outline form of the plate, that all movable tissues that would tend toward displacement of the plate might be

[1] "American Textbook of Prosthetic Dentistry."

avoided. The appearance of the finished piece would be ruined if subsequent to its completion it would be necessary to trim down the plate with a turned rim, owing to its faulty outline, and this condition might easily arise if due regard were not given in the first place to the outline of the plate.

Swaging the Plate.—When the various steps of the preliminary procedure have been satisfactorily complied with, and the platinum plate, 32 to 36 gauge, depending upon the form and size of the plate, cut to the form of the pattern previously prepared, its conformation to the die may be begun.

The platinum is well annealed, and, after covering the face of the die with a thin piece of moist muslin, the plate is first adapted to the vault by pressure applied with the thumbs. When the adaptation has been made as close as possible by this means, a few gentle blows of the mallet will aid in securing a closer adaptation. It is necessary to observe the same strict precaution to prevent particles of base metal from becoming attached to the platinum, as was noted in regard to the swaging of gold plates (see chapter on Swaged Metallic Plates). If these particles become attached to the plate and are allowed to remain in contact with it, a hole is likely to be formed in the platinum in the subsequent annealing of the plate, or the oxids of the base metals may discolor the porcelain in the fusing process. Placing the plate in the acid bath, and covering the face of the die with a thin cloth, are the means utilized to guard against the danger. The plate should be repeatedly annealed and be made to conform to the vault as closely as possible. When this has been accomplished, a partial counterdie[1] may readily be

[1] "American Textbook of Prosthetic Dentistry."

formed by adapting softened modeling composition to the vault of the plate, and hardened by applying cold water to its surface. By this means the plate is retained in close adaptation to the vault, while the alveolar portion is adapted to the die. When the plate has been conformed to the die as closely as the means indicated will allow, the final adaptation should be made by swaging between the die and counterdie. On no account should the platinum come in direct contact with the die or counterdie in the swaging process. The reasons for this have been previously discussed. It is well at first to lightly swage the plate and examine it. If any wrinkling of the metal has taken place, the plate should be removed and the fold corrected; or if the metal has been torn, a piece of 36 gauge platinum is placed over the tear and the opening closed by soldering the piece to the plate with 25 per cent. platinum solder.

If the rim is to be turned the plate should conform to the exact plate outline designated upon the cast, making the necessary allowance for the turning of the rim so that trimming might be avoided after the completion of the plate. Some operators prefer attaching a wire to the border of the plate and trimming the plate to the exact plate outline, and then soldering the wire in position. With the wire in position the plate may be trimmed subsequent to its completion, if this should be necessary.

Reinforcement of the Plate.—The lack of rigidity characterizing platinum makes it necessary to reinforce the plate to prevent its distortion either from the heat to which it is exposed in fusing the body, or from the force of mastication. The portions of the plate requiring reinforcement are the posterior border and the median portion of the plate posterior to the alveolar bor-

der. This latter piece is not regarded as being necessary by all who construct continuous gum dentures. It is a safe precaution, however, and, while it slightly adds to the weight of the finished piece, this is to be preferred to a possible distortion of the form of the plate, which may occur if this piece is not added to the plate. Fig. 299 illustrates the form of the reinforcing pieces, which are cut from iridio-platinum plate 24-26 gauge. The triangular piece for the median portion of the plate posterior to the alveolar border is annealed and conformed to the die by the mallet and swaging, after which it is placed in position upon the plate, and both swaged between die and counterdie, the usual precautions being again taken to carefully protect the plate from direct contact with die or counterdie.

FIG. 299.—SHOWING WIRE SOLDERED UPON TOP OF RIDGE AND TEETH SOLDERED ON, ALSO REINFORCING PIECES. ("American Textbook of Prosthetic Dentistry.")

The piece for the posterior border of the plate is cut to the form shown in the illustration, about 3/16 of an inch wide. In addition to strengthening the posterior portion of the plate, this piece is also intended as the finishing piece for the porcelain in this region. To adequately meet these requirements the anterior portion of the reinforcing piece should not be in contact with the plate, but raised, while the posterior two-thirds of the piece should be adapted to the plate. To accomplish this double relation easily it is advised [1] to first swage a piece of brass to conform to that portion of the plate imme-

[1] "American Textbook of Prosthetic Dentistry."

diately anterior to the position intended for the reinforcing piece. The posterior edge of the brass piece is trimmed down to a feather edge. The iridio-platinum piece is then conformed to the die, and swaged with the plate in position upon the die, as recommended for the median piece, excepting that now the brass piece is interposed between the plate and the reinforcing piece, and the three pieces swaged together. When swaged and the brass piece lifted from its position, it will be found that the anterior border of the platinum reinforcing piece is raised from the plate, while its posterior border is in contact with it. The plate and reinforcing pieces are now placed in the acid bath, washed, and ready for the soldering. If the wire clamps are used to hold the pieces in position during the soldering, the precaution should be taken that the clamps are not allowed to press too hard upon the plate, which, if allowed, might easily cause distortion of the form of the plate during the soldering, for reasons previously discussed (see chapter on Swaged Metallic Plates). When the anterior piece has been satisfactorily adjusted, small pieces of platinum solder are placed along the joint, and when the case has been thoroughly heated, the fine flame of the oxyhydrogen blow-pipe will readily cause the solder to flow. When the joint has been closed, the posterior piece should be soldered to the plate, following the procedure outlined above. The plate with the reinforcing pieces permanently attached may now be placed upon the cast and its adaptation noted. If found to be as desired the plate is tried in the mouth, and should conform to all the requirements as discussed in Chapter XXXIII. When a satisfactory test has been made, the next step in the procedure is the taking of the bite, for the details of which the reader is referred to Chapter XXX.

Selection and Soldering of Teeth.—Having obtained the bite and mounted the case upon the articulator, the artificial teeth are next selected. These are especially prepared for continuous gum work, having one long platinum pin for each tooth, the roots of the teeth being also represented in porcelain, as shown in the following illustration. The extension of the porcelain in the form of the

FIG. 300.—BASE PLATE WITH TEETH ARRANGED UPON IT. ("American Textbook of Prosthetic Dentistry.")

root is necessary to establish the contact of the tooth with the plate; it also aids toward the artistic effects of the finished piece. While the teeth especially prepared for this work are generally employed, if the conditions indicate the use of a short tooth those used in vulcanite work may be substituted. But little need be said here concerning the artistic effects that may be obtained in the arrangement of the teeth, and the reproduction of various defects commonly observed in mouths which, when reproduced upon the artificial denture, materially aid toward giving the case that "natural appearance" which is the most effective cloak for its artificiality. As has been stated in a preceding chapter (see chapter on The Bite), the degree of success obtained in this regard depends upon the artistic capability of the prosthetist, and in most cases the details discussed in books are but a small factor in the success realized in this relation.

Emphasis, however, should be laid upon the possibilities in the artistic results, especially in continuous gum work, and each case should be treated with thorough and earnest study for the best possible results. Having arranged the teeth as appears most desirable, and restored the normal contour of the lips and cheeks, the case should be tried in the mouth. If the arrangement of the teeth, the contour, and articulation are satisfactory, the case is removed from the mouth, and preparations made for the attachment of the wire to the plate, to which the teeth are subsequently soldered.

Dr. Le Cron advocates the use of No. 16 iridio-platinum round wire instead of the platinum backing frequently used as the means of attaching the teeth to the plate with solder, and claims that when the porcelain is later added it better adapts itself to the wire, and shows less tendency to crack.

To adjust the wire to the plate a guide of modeling composition or plaster of paris should be prepared for the teeth; when this has hardened the wax sustaining the teeth in position may be removed, exposing the ridge of the plate and the pins. The wire is now adjusted under the pins and waxed in position. The teeth and modeling composition are removed from the plate and the wire soldered to position. The guide with the teeth in position is returned to its proper place upon the plate, the pins bent down to be in contact with the wire, and waxed in position. The case is then invested and ready for the soldering.

The investment best adapted for continuous gum work consists of fine asbestos, 1 part; coarse calcined silex, 1 part; plaster of paris, 2 parts.[1] Prior to add-

[1] "American Textbook of Prosthetic Dentistry."

ing the investment it is recommended[1] to paint with shellac varnish the surfaces of the teeth to be invested. This prevents the fusing of the investment with the porcelain during the soldering process.

When the case has been invested and the investment material has hardened, the wax is removed, the pins brought into contact with the wire and plate, and the relation made permanent by flowing platinum solder over the parts. When the case has cooled the investment is removed and the plate boiled in the sulphuric acid solution until thoroughly cleansed. When this has been done the case is again tried in the mouth to finally determine its adhesion and the articulation of the teeth. If these are satisfactory the case is ready for the addition of the porcelain.

The Addition of the Porcelain Body.—Before adding the porcelain body to the plate, the surface about to receive the body should be made absolutely clean by means of alcohol, that the porcelain may not be discolored by foreign substances remaining upon the surface of the plate. It is also well to roughen the surface of the platinum with a sharp instrument for the better retention of the body. When these details have been satisfactorily followed the case is ready for the addition of the body. This is considered in three stages. The application of the first layer is the most important, as upon its correct manipulation the final results are largely dependent.

The body is selected and mixed with distilled water to a thick, creamy consistency, and applied to the palatal portion of the plate about and between the teeth, in a layer of even thickness. The body should be jarred into place, and the moisture appearing upon the sur-

[1] "American Textbook of Prosthetic Dentistry."

face of the body when the plate is jarred should be absorbed with pieces of blotting paper. The labial and buccal portion of the denture is treated similarly, and when the thickness of the body is about equal to 24 gauge plate the form of the rugæ may be reproduced, as well as any other special feature that the judgment of the practitioner may indicate. When this step in the procedure has been reached, suitable provision must now be made to guard against the distortion of the form of the plate or the arrangement of the teeth, which otherwise would surely take place owing to the contraction of the porcelain body. The plan of procedure is to separate the body by passing a sharp instrument between the teeth and into the lingual portion of the plate. In this manner space is provided for the contraction of the body and the dangers previously alluded to avoided.

Before subjecting the case to the first "bake," it should be thoroughly dried by placing it before the door of the muffle. When this has been accomplished the denture is placed within the muffle and allowed to remain there for five minutes with the lever of the rheostat on the first button. The heat of the furnace is then raised by adjusting the lever to the next button and to the following ones, allowing about two or three minutes before making the successive adjustments. The object of the first baking is to carry the process of fusion to the "biscuit stage," at which point complete contraction in the body has occurred without the glaze which accompanies complete vitrification. When the "biscuit stage" of the first baking has been reached the rheostat is turned back and the case slowly cooled by turning off the current. When cooled the case is placed upon the die and the rim turned to the desired angle, that the proper finish may be obtained in the completed case.

The case may now be prepared for the second baking. All the open spaces are filled in, and the contours worked up with the body applied in the same manner as previously indicated. The case is then placed in the furnace, the heat gradually applied as before, and the fusion of the porcelain brought to a more complete state than in the first baking, by slightly increasing the temperature of the furnace. The body should now just begin to show a glaze. When this has been attained, the case is allowed to cool, and tried in the mouth to observe if the contour is as desired, or if any change in its form has taken place. If satisfactory the case is ready for the application of the gum enamel.

Application of the Gum Enamel.—The gum enamel is mixed with distilled water, thinner than the preceding layers, and the denture should be wet to facilitate the application of the enamel, especially beneath the rim, where there is danger of the enamel flaking during the fusing process. The lighter and darker shades of the gum are reproduced by varying the thickness of the application, the lighter shades of the gum being reproduced by the thinner layers of the enamel mixture. When the mixture has been satisfactorily applied, it is again thoroughly dried and placed within the muffle. It must now be carefully observed that overfusing should not occur. When properly fused the case presents a highly glazed appearance with a natural appearing colored gum. If overfused the normal coloring is lost. The formation of fissures is to be treated by filling in the spaces and repeating the fusing process.

The discolorations observed in worn down and devitalized teeth, or arising from any other cause, may be reproduced by means of *mineral paints,* and afford the

opportunity for increasing the natural appearance of continuous gum dentures.

Partial Dentures.—While partial continuous gum dentures are rarely constructed, not only because the technical difficulties of construction are somewhat greater, especially in regard to the swaging of the plate, than in full cases, but seldom do the esthetic and hygienic requirements of the case call for this form of construction. In those cases, however, where this type of denture appears desirable, its construction may be undertaken.

For partial upper cases covering the entire surface of the hard palate the procedure is first to swage the plate of about 34 gauge platinum plate to conform to the outline prepared for the plate. In swaging the plate, as previously indicated, care should be taken to guard against the folding or tearing of the plate, which is quite likely to occur in adapting it to the natural teeth. When the primary plate has been swaged it is to be reinforced by swaging a second piece of 30 gauge iridio-platinum to conform to the palatal portion of the first piece, but need not extend over the ridge. The two pieces are next to be swaged together and united with platinum solder, the lateral margins of this piece being arranged to form the lingual wall for the porcelain. The rim for the posterior portion of the plate is not here required, as the porcelain is not added to the palatal surface, as it is in full cases. The buccal rim is formed in the usual manner. When the partial denture is retained by clasps it is to be constructed of somewhat heavier gauge metal, 26 gauge iridio-platinum being used for the second piece. The clasps are to be constructed of iridio-platinum, as indicated in chapter on The Principles of Retention, and attached to the plate with platinum solder.

For partial lower cases the general principles underlying the construction of this type of denture are similar to those considered in relation to partial upper cases. Where the posterior teeth are to be replaced sufficient strength must be given the finished piece; therefore, the reinforcing piece is swaged from 24 gauge iridio-platinum plate. The rim is formed by attaching 18 gauge platinum wire to the margins of the plate, and, as the porcelain is not adapted to the anterior lingual portion of the plate, the wire is also attached to the plate in the region setting the boundary to the porcelain.

Repairing Continuous Gum Dentures.—The electric furnace has greatly simplified the former difficulties of making repairs of continuous gum dentures. In some instances where a distinct line of fracture of a tooth exists, Dr. Le Cron[1] claims that quick and satisfactory results may be obtained by first thoroughly cleansing the case, by washing the denture in a solution of ammonia water, investing it in a combination of asbestos and plaster, and gradually heating to redness over a gas stove. The heat carbonizes the retained organic matter in the recesses of the plate, and after the plate has cooled the investment is removed, the case washed with soap and water, and further cleansed with alcohol. When thoroughly cleansed liquid silex is applied to the two surfaces of the tooth, the fractured portion pressed into position, and the case again heated to an orange-red color.

In replacing an entire tooth the porcelain upon the lingual surface of the plate is ground until the platinum is exposed. Sufficient room is provided upon the labial or buccal surface to admit the correct placement of the

[1] "American Textbook of Prosthetic Dentistry."

new tooth. A suitable tooth is selected, ground to meet the requirements of the case, and sustained in position by means of wax. The case is then invested, and the tooth attached to the plate by means of pure gold, which is fused by placing the case in the furnace and heating it until fusion of the gold occurs.[1] This is a better plan than soldering the tooth with the blow-pipe, the use of which is likely to endanger the porcelain upon the plate.[2] The porcelain is then applied as previously indicated.

The Use of Tube Teeth.—M. B. Platschick of Paris originated a very effective method for the utilization of tube teeth in relation to continuous gum, avoiding the necessity of first attaching the teeth in position with solder, as previously indicated.

A platinum plate is first swaged to the requirements of the case. This is reinforced by a second piece made to fit the ridge, or places where the pins which support the artificial teeth are to be located. The two pieces are soldered together and the plate tried in the mouth. When satisfactorily adapted platinum wire of special form is soldered to the alveolar border of the plate to form the rim. The form of the wire after it is attached to the edge of the plate forms a recess for the attachment of the porcelain. The tube teeth are selected and adjusted to position. When in their desired positions a plaster guide is formed, the wax removed, and a sharp instrument passed through the perforation of each tooth and a scratch made upon the plate locating the position of the pins. Iridio-platinum wire of a gauge to correspond to the diameter of the perforation of each tooth is fitted and soldered in its correct position. When this step in the procedure has been accomplished the plate

[1] "American Textbook of Prosthetic Dentistry."
[2] *Ibid.*

is thoroughly cleansed and the porcelain added. The body is mixed into a paste and a portion of this is applied around each pin, and the teeth forced into position. Additional porcelain body is applied to the necks of the teeth and to the openings upon the occlusal surfaces. When the teeth have been fixed in position by one or two bakings, the body and gum enamel are added according to the method previously described.

CHAPTER XXXVI

PALATAL MECHANISM

Definition.—By palatal mechanism is meant the construction and application of a device to a cleft palate whereby the patient is able to reproduce the normal sounds of speech, which could not be done previous to the adjustment of the appliance.

Principles of Construction.—The principles underlying this type of construction depend upon the proper formation of the sounds of words; therefore, the device must be constructed with the view that its utilization will enable the patient to normally articulate.

Under the condition known as "cleft palate" the provision which normally exists for guarding against the inrush of air into the nasal cavities is destroyed, and unless the device is constructed to effectually simulate the functions performed by the natural velum, or soft palate, the normal sounds of words cannot be reproduced.

In the production of certain sounds the natural velum, by being drawn upward and backward, tightly rests against the posterior portion of the pharynx, effectually occluding the nasal cavities, thus preventing the air from entering into them and producing the abnormal nasal sounds. Besides this important function the natural velum subserves a second, scarcely less important than the former. This function is to provide a

resting place for the tongue in its elevation in the production of certain sounds. Hence, when the condition of "cleft palate" exists, the patient is unable to guard against the indistinct nasal sounds caused by the air rushing into the nasal cavities in the act of articulating certain sounds, and the inability to normally reproduce many other sounds, owing to the abnormal relations assumed by the tongue in its upward movements. In many instances the defects may be successfully corrected in the construction of an *artificial velum,* or an *obturator,* either of which may be successful in definite cases. In other instances the efforts of the dentist are quite unavailing. It will be in order, then, to briefly consider the condition known as cleft palate.

Cleft Palate.—The perforation of the hard, or of the soft, palate, or of both, which the term "cleft palate" implies, is divided into two classes, *acquired* and *congenital.*

The acquired cases are those which occur after birth, and are usually due either to syphilis or to surgical operations for the removal of cancerous growths, or to accidents. The extent of the perforation varies considerably. From a slight perforation of the hard palate to the extreme condition of perforation of hard and soft palate with loss of the vomer, turbinated, and nasal bones, between these an almost endless variety of intermediate conditions may present; for some of the more serious cases but little can be done to promote normal enunciation.

Congenital cleft palate is the condition, previously indicated, existing at the time of birth, and upon examination will be found to be a cleft of the soft palate only, or simply a division of the uvula; or the perforation may

affect the soft and hard palate, but slightly affecting the bony structure; or the cleft may completely involve the hard palate and extend through the dental process. In those cases in which surgical procedures have been applied in the hope of closing the cleft, but without success, the soft tissues, posterior to the hard palate, will be found drawn together, and so strained as the result of the means adopted to bring the edges of the cleft together that they are unable to be drawn upward and backward to tightly occlude with the posterior portion of the pharyngeal wall, the position assumed by the natural velum, as previously indicated, to prevent the nasal resonance in the production of certain sounds. In many of these cases the cleft in the hard palate remains, while in others the cleft in the soft palate is ineffectually closed, and the case, owing to the restricted movements of the soft tissues, is increasingly difficult, if not altogether impossible, of correction.

Devices for Correction of Defects due to Cleft Palate.—As stated, the construction and application of a device to correct the defects of speech resulting from a cleft palate is defined as "palatal mechanism"; the device itself is defined as an *artificial velum,* or an *obturator,* according to the type of device constructed. It is claimed[1] that "the artificial velum will more quickly enable a cleft palate patient to acquire the art of speaking correctly, while after having learned to speak properly the obturator may afford him equal satisfaction." The *artificial velum* was first introduced by Dr. N. W. Kingsley and is made of soft rubber, i. e., rubber that is but partially vulcanized, which results in the formation of an appliance which readily responds to the movements of the muscles to which it is adapted, moving up-

[1] "American Textbook of Prosthetic Dentistry."

ward and downward in the same manner as does the natural velum; it also simulates the relation of the natural velum with the pharyngeal wall, effectually closing the openings leading into the nasal cavities. Fig. 301 illustrates the Kingsley velum. It consists of an upper and lower flap, triangular in shape, joined along the median line, and grooved out laterally for the reception of the two edges of the soft palate. The flaps are triangular in shape, as stated, which is the usual form given the flaps when the soft palate alone is involved in the cleft, but when the hard palate also is involved, in many cases it is a better plan to fill the opening in the hard palate by making a hard rubber attachment upon the upper surface of the plate; the anterior portion of the artificial velum should then have a square end to meet a like surface of the rubber attachment upon the plate.

FIG. 301.—THE KINGSLEY VELUM.

When in position in the mouth the lower flap of the velum is continuous with the palatal tissues, and extends from the anterior edge of the cleft posteriorly to the bases of the uvulæ. The flap is made wide enough to rest against the soft tissues, and resist the ordinary forces acting upon it from pushing it into the cleft. The upper flap resembles in form the lower, except that its posterior border is curved and conforms to a feather edge, "so that when in occlusion with the pharyngeal wall it curls up, thus presenting a flat surface for better contact, while its thinness prevents irritation to these sensitive parts."[1]

Fig. 302 illustrates the velum in position. It is attached to a metal plate, which is retained in position

[1] Dr. Ottolengui.

FIG. 302.

by means of clasps; the plate is constructed with a headed pin attached to its palatal surface which engages an opening in the velum, preventing its dislodgment, while it does not interfere with its lateral movement. Fig. 303 illustrates the attachment to the velum of the plate. In describing the principle of action, Dr. Ottolengui [1] writes as follows: "In the effort to close off the upper passage the sides of the divided natural palate approximate each other, and at the same time are drawn upward. Thus they first hug the artificial velum tightly and then, owing to its elasticity, carry it upward. Coincidently, the wall of the pharynx rises, forming a ridge which meets the feather edge of the artificial velum, curling it up, thus accomplishing perfect contact, completely preventing the escape of sounds through the nasal passages. At the same time the velum, completing the proper arch of the vault, is rigid enough to serve as an efficient abutment for the tongue when necessity compels such contact."

FIG. 303.

An obturator is a hollow device constructed of hard rubber to fill the opening in the palate. Irrespective of the distance the edges of the cleft are drawn upward, the posterior nares must remain occluded, otherwise the device does not satisfactorily meet the requirements of

[1] "American Textbook of Prosthetic Dentistry."

the case. In order to attain the result for which the appliance is constructed, the obturator must be sufficiently thick; that is, its diameter up and down must be long enough (the obturator being hollow), so that when the edges of the cleft are drawn upward the greatest possible distance they are still in contact with the sides of the obturator. It must also extend sufficiently far backward that it can be reached by the posterior wall of the pharynx, and thick enough at the posterior portion that, when the pharynx comes in contact with it, the nares will be satisfactorily closed. Fig 304 illustrates an obturator in position. It is attached to an iridio-platinum plate by passing over a threaded bar soldered to the plate, and held securely in position by the adjustment of the nut. The following illustration shows the appliance out of the mouth.

FIG. 304.

FIG. 305.

The inclination of those with greatest experience in palatal mechanism appears to be strongly in favor of the use of the artificial velum, and, while satisfactory results may be obtained in the use of the obturator, better results will be obtained in the use of the artificial velum. This conclusion is made especially emphatic in regard to the choice between the artificial velum and

obturator in relation to young children with cleft palates.

In 1902 Dr. Calvin S. Case introduced a new form of device intended for cleft palate patients, which he described as follows:

"Through a desire to take advantage of the benefits afforded by a soft rubber appliance on the one hand, and a hard rubber obturator on the other, and at the same time avoid the possibilities of the final inefficiency of the one and the difficulties in construction and adjustment presented by the other, has risen the present artificial palate, which it is the object of this paper to present.

"It essentially consists of a form of palate which can first be made of soft rubber and possess all the advantages of the Kingsley velum, and then when the patient has become accustomed to it in its flexible state, and its form is an assured success, by packing the same casts in which the soft rubber palates were vulcanized with another quality of rubber, a hard rubber palate is produced which possesses all the advantages of a perfect obturator.

"If made of soft rubber the first palate can be worn without irritation or special inconvenience; after which desired changes in its form, that are nearly always required to perfect the palate, can then be easily made by slightly enlarging or contracting the metal mold in which it is vulcanized.

"Those who are familiar with the Kingsley palates, which I am pleased to say I have used with great satisfaction in my practice for over twenty years, will remember that the veil or posterior portion of the palate is sustained by extending the central thickened portion into it, and from this point it is gradually flattened to a comparatively thin edge, where it is more or less

curved in conformity to the pharyngeal wall, against which it is intended to rest during the contraction of the pharyngeal and the palatal muscles.

"In this particular it is quite different in form from the palate I am about to describe, in that with the latter all the central portion of the palate is thin; while the edge of the veil is thick, in the form of a solid roll about one-fifth of an inch in diameter, or preferably triangular, with rounded corners, so that its outer flattened surfaces exactly and firmly fit the pharyngeal walls *when the muscles are in a contracted state.*

"Fig. 306 represents the palatal view of the artificial palate, with transverse section.

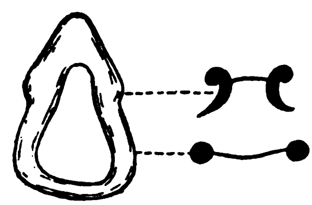


FIG. 306.

"In extensive clefts the borders of the veil extend forward along the lateral walls of the pharynx and posterior nares, and, becoming thinner, form the borders of the nasal extensions which rest upon the floor of the nares.

"When the cleft does not extend into the hard palate, the veil is shaped in a similar manner, but with the nasal portion abridged to meet the requirements of the case. Where the cleft extends into the hard parts, the body of the palate which covers the borders of the cleft and forms the lateral wings on the roof of the mouth should not extend back of the attachments of the bifurcated velum palate, nor in any way interfere with the free action of the muscles; neither should it extend upon the roof of the mouth any farther than is necessary to give a firm seating for the palate. This portion should be about as thick as an ordinary rubber plate, being

thinned along its oral borders and thickened to form the nasal borders.

"There are a number of important advantages in this form of palate, even when made of flexible rubber and used for the purposes of a velum.

"*First.*—The early deterioration of the rubber, causing the curling up of thin edges of the veil, is entirely prevented. When this occurs, as it frequently does with ordinary vela, the vocal usefulness of the palate is impaired, if not destroyed, in proportion as it permits the escape of air at the curled-up portion of the border.

"*Second.*—The heavy border of the veil is sufficiently yielding and flexible to be worn with comfort if properly fitted, and it also presents sufficient stability and breadth of surface to permit firm contact of the pharyngeal muscles in closing the naso-pharyngeal opening.

"*Third.*—In more or less extensive clefts the thin central portion extending forward into the body of the palate permits a resilient yielding of the lateral portions of the body, which frequently allows one to spring it into place with sufficient grasp of the irregular borders, along which it should accurately fit, to hold it in position without the aid of supporting plate. Whenever this can be accomplished with the soft palate, it will readily be continued when it becomes hard."

More recently Dr. Ottolengui described[1] his modification of the Kingsley velum. In Dr. Ottolengui's appliance, which he defines as a velum "obturator," the tail piece is entirely different from that of the Kingsley velum, while in general shape it closely resembles that appliance. In the Kingsley velum, as previously noted, the posterior border of the upper portion of the velum is formed to a feather edge, and bends over as the pos-

[1] "American Textbook of Prosthetic Dentistry."

terior wall of the pharynx occludes with it. Dr. Ottolengui's appliance is constructed upon a model which shows the pharynx to be closed, thus the portion of the appliance in relation with the posterior portion of the pharynx presents a broad surface of contact which is regarded as being distinctly advantageous in many cases.

The forms of artificial palates as here discussed are to be preferred to the form in use in former times constructed with a hinge, for which arrangement special advantages were claimed, but which it was soon ascertained were unfounded.

Experience has now quite clearly established that in most instances the greatest benefits to cleft palate patients will accrue from the use of the soft rubber velum. Having once learned to enunciate clearly, good results will follow the use of any other form of appliance. But preëminent as the artificial velum may be in cases of cleft palate, cases may present where the early hinge form of adjustment is a necessity. This occurs where "the apex of the fissure is distant from the posterior border of the hard palate."[1] In these cases, viz., where some distance intervenes between the posterior border of the hard palate and the apex of the fissure, it is claimed that "the soft velum, lying entirely upon the upper surface of the cleft, and the anterior edge of the velum being stiff and wide, while the apex of the fissure presents the usual angle, it follows that *the natural palate cannot rise without carrying the superincumbent velum with it.* This it could not accomplish if the extension which connects the velum with the plate were unyielding."[2] Hence, in these instances the hinge is imperatively indicated.

[1] Dr. Ottolengui. [2] *Ibid.*

Taking the Impression.—If the impression for a cleft palate case could be taken as the ordinary impression for a denture is taken, that is, with no greater inconvenience to the patient, many failures that heretofore have attended the efforts of those attempting the correction of the defects of cleft palate would not have been recorded. While the related factors here are in a way entirely different from those of the ordinary impression for a denture, but slight inquiry is necessary to impress the fact that an *accurate impression* of the cleft soft palate *in its relation of rest* is an impossibility. This becomes clear when it is realized how quickly the soft palate is drawn away from contact with any substance by the action of the involuntary muscles of the throat. Hence, as soon as the impression material is pressed into contact with the natural velum it is drawn away from the impression material, and a model prepared from such an impression would not show these parts in a state of rest. It is claimed by some writers[1] that a divided velum is more sensitive than the normal one, hence, the disturbance following contact with the impression material is here even greater. The two halves of the divided velum are not only drawn upward, but the opening between them becomes narrower, which relation is reproduced upon the model, but is not the relation of the two halves when at rest, so that, as previously stated, a perfectly accurate impression of the deformed velum in a state of rest is most improbable, if not impossible. However, if the model is subsequently altered, as will be described later, very satisfactory results may be obtained.

In taking the impression the tray is selected in the usual manner, and if it appears desirable an extension

[1] Dr. Ottolengui.

of gutta percha may be made at the posterior border of the tray for the better accommodation of the impression material. If the tray is selected as recommended in a previous chapter, its posterior border will extend somewhat beyond the line of the hard palate, and, while this may be adequate for taking the impression of the parts, the extension of gutta percha as suggested may be made. Plaster of paris is mixed as recommended in the chapter on Impressions, applied to the tray, and, just as the material gives indications of hardening, it is introduced into the mouth, quickly adjusted to position, and as soon as the material has hardened sufficiently it is removed. It should not be retained in position for too long a time, as this might render its removal somewhat difficult, especially in those cases where the cleft involves the hard palate, and the plaster is forced into the nasal cavity, and this portion of the impression cannot be withdrawn without fracture. If the plaster "sets" too hard before the attempt at its removal is made, the fracture will not occur without considerable annoyance to the patient. In constructing an artificial velum, where the cleft slightly involves the hard palate, it is a good plan to force a small quantity of the plaster mix into the nasal cavity, prior to the introduction of the tray for the main impression. This is done to locate the vomer, the insertion of which into the hard palate may be very close to the apex of the cleft, and when the velum is placed in position its upper portion might unduly press against the bone, unless this precaution of locating the vomer is adopted in the first place.

When it is considered advisable to secure an accurate reproduction of the nasal cavity, in those cases where the cleft involves the greater portion of the hard

palate, the procedure is first to fill the nasal cavity with plaster mixed stiff, and, when the plaster has reached the borders of the cleft, the tray which has been previously filled with plaster is carried to position. The plaster upon the tray will unite with that in the nasal cavity, and, if the tray is withdrawn as soon as the plaster admits of a sharp fracture, the piece in the nasal cavity is then removed, and subsequently adjusted to place upon the plaster impression; or, the nasal cavity may be filled as indicated, and the plaster allowed to set. It is then removed, varnished, replaced, and when the tray is introduced to secure the impression of the remaining parts, union between the two portions of plaster does not take place; hence, but little difficulty exists in removing the impression, although more time is consumed in obtaining the final result.

If the operator intends constructing an appliance similar to the one introduced by Dr. Case, it is recommended that the impression should be taken in the following manner, as suggested by Dr. Case:

"In taking an impression for the construction of this palate where the cleft is extensive, or even extending somewhat into the hard palate, it is my object to obtain a perfect model of that portion of the roof of the mouth over which I wish the palatal portion of the plate to extend, and along the borders of the cleft forward of the pendent portions of the velum palati, extending somewhat upon the floor of the nares and representing as perfectly as possible the nasal borders of the cleft and lateral surfaces of the posterior nares.

"These surfaces, a part of which lie above the pendent and unstable tissues of the velum palati, are frequently susceptible of being perfectly reproduced in the

model of a plaster impression. It will usually be found in a typical case that the posterior nasal openings are laterally constricted, from which point the nasal fossæ widen to form the floor of the nares. By obtaining a perfect impression of these somewhat unyielding surfaces, which otherwise on account of their position would be very difficult to reproduce, the anterior borders of the artificial veil can be perfectly fitted to them as they merge into the nasal borders of the body.

"I lay particular stress upon this portion of the operation because I have found it important, not only as a great aid to the proper action of the pharyngeal muscles, but in clefts of considerable extent the overhanging nasal borders of the artificial palate can be easily sprung into place, and when fitted perfectly patients soon learn to place and sustain the palate without the aid of a supporting plate.

"I would advise, however, that the supporting plate be always made, to enable patients to more readily adjust and sustain the plates until they have learned to wholly do without it.

"When no artificial teeth are required, or when, if required, a bridge denture is practicable, the supporting plate should be made to cover as small an area of the roof of the mouth as is consistent with the demand for strength. I rarely extend it forward of the second bicuspid, leaving as much of the anterior palatal surface exposed as possible, which I believe materially aids in acquiring perfect enunciation.

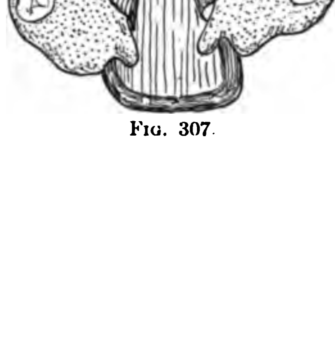


Fig. 307.

"Fig. 307, which is made

from the model of an impression of the mouth with the apparatus in place, shows the form of the supporting plate I usually make.

"There are two ways of taking these impressions: one by forming a base of modeling compound upon which to lay the plaster, and the other by using plaster alone.

"For the first the compound is wrapped around the forefinger and pressed gently to place. Removing, softening, and perhaps slightly reshaping and cutting away surplus, this is repeated several times, with the view of finally obtaining a modeling compound impression that will not displace the soft posterior borders, and that will perfectly support the plaster for the final impression.

"The palatal surface is then roughened so the plaster will cling to it, and all that portion of the compound which extends above the nearest approaching borders of the cleft is cut away and the cut surface smoothed and oiled.

"This, when carried to place with the plaster in position, need cause no fear of its easy removal, even though an excess of plaster is used—providing it does not come forward of the alveolar ridge in extensive double clefts—as all that portion which extends above the border of the cleft forming the impression of the nasal fossæ will readily break from the smooth, oiled surface of the compound, when the impression is removed, it being otherwise unattached to the lower parts, as the compound completely bridges the cleft from its nearest approaching borders. The nasal section can then be teased back toward the more open portion of the cleft, and allowed to fall on a mouth mirror, from which it is replaced upon the impression.

"As a rule I prefer plaster alone, dividing it as

above in sections at the borders of the cleft. The first section is passed freely into the nasal cavity with a spatula, stopping it abruptly at the nearest approaching border of the cleft. The under surface is then lubricated with a solution of white vaselin, and the first part of the second section is delicately laid on with the spatula, so as to not lift or dislodge the upper section. The plaster is spread out over the roof of the mouth with a spatula, and when partially hard is strengthened for removal with fresh plaster introduced in a flat impression tray. The impression does not need to extend even to the gingival borders of the teeth.

"In filling and trimming the casts from these impressions, nearly all that portion back of the attachments of the soft palate is cut away, and the nasal portion of the cast opened and freely exposed to the extreme nasal borders, produced by the impression. This is done to facilitate shaping the modeling compound model or pattern of the palate, and its ready removal from and replacing upon the cast during the process of repeated trials in the mouth."

Where a small opening exists in the palate, owing to disease or some other cause, if a plaster impression is desired of the case some means must be provided for preventing the plaster from entering the opening, and then, by extending beyond its borders upon the nasal side, it becomes a difficult matter to remove this portion of the impression. It is recommended,[1] in these cases, to place several folds of Japanese tissue paper across the opening in the palate, which will prevent the plaster from entering the opening as indicated, and yet admit of it entering sufficiently far for a desirable impression.

[1] "American Textbook of Prosthetic Dentistry."

In those cases in which all, or nearly all, of the separation normally existing between the nasal and oral cavities is lacking, the cavities being continuous, and where an irregular outline and convolutions characterize the condition, the following procedure is recommended:[1] "A sheet of gutta percha is softened and trimmed to approximately cover, let us say, the right half of the cavity extending below, over the alveolar ridge or teeth, if these organs be present. Using this as a tray an impression of the right half is easily procured and a model made. On this model a wax plate is fashioned and reproduced in vulcanized rubber. This rubber plate is tried in the mouth, and any angles that might cause irritation or render removal difficult are carefully filed away, until the plate rests comfortably against the right half. With this in place plaster is then pressed against the left side and partly over the rubber plate. When hard the two are removed separately, waxed together, and a model made over them both. A plate of vulcanite is now made for the left side, both being united in the vulcanization, so that we now have a shell of thin vulcanite rubber which will fit the whole interior of the cavity. This is next filled with plaster carved so as to form a representation of a normal vault when in place. With this surface oiled to prevent adhesion of new plaster, the shell with its filling of plaster is placed in the mouth and an impression taken as of a normal mouth. The model from this will have the shell of vulcanite in place and still retain the filling of plaster. Using this as any regular model, a set of teeth (if teeth be required) is made, and in the course of vulcanization this final rubber plate attaches to the shell which lines the upper cavity. On removal from the flask a hole is

[1] "American Textbook of Prosthetic Dentistry."

cut opposite the nostrils, and another at the back, and through these holes the plaster filling is dug out, leaving a set of teeth having a hollow superstructure of vulcanite which closely fits against all the upper surfaces. A plate of this character usually stays in place quite fixedly. The two holes supply breathing apertures."

The Treatment of the Model.—As has been previously stated, an absolutely accurate impression of a cleft velum, in its relation of rest, is an impossibility, but satisfactory results in the finished piece can be obtained if the imperfect model is corrected.

Dr. Ottolengui[1] advises that a trial plate be made of a double layer of gutta percha, and conformed to the model. The first layer is extended into the cleft as it appears upon the model. A piece of copper wire is next formed into a loop, and pressed into the trial plate, the loop extending into the gutta percha fitted into the cleft. The second layer of gutta percha is now adapted over the first, and, with the copper wire between the two layers, a stiff trial plate is secured, which can easily be conformed to any desirable shape. When this trial plate is placed in the mouth, it at once becomes evident that the model very imperfectly reproduces the normal relations of the cleft. The cleft will be seen to be wider, and its sides will fall below the extended portion of the trial plate, showing that the sides of the soft palate are drawn upward as the impression material is placed against the tissue. The extended portion of the trial plate is bent downward until it follows the normal lines of the palate when at rest, and as stated[2] in some instances it is only after persistent effort that the muscular effort which draws upward the sides of

[1] "American Textbook of Prosthetic Dentistry."
[2] "American Textbook of Operative Dentistry."

the cleft will finally cease, and admit of the true lines being ascertained. Wax is next added to the sides of the extended portion of the trial plate, and, by repeatedly replacing it in the mouth, the true lines of the natural palate are secured. The trial plate is now placed upon the model, which must be trimmed to widen the cleft to accommodate the reshaped extended portion of the trial plate. The edges of the cleft upon the model are now built up by additions of plaster of paris until they just reach to the wax of the trial plate. When this procedure has been carefully followed the divided natural velum may be quite accurately reproduced.

Dr. Ottolengui also claims [1] that, in those cases where the activity of the muscles is so marked that in the act of swallowing the pharyngeal muscles come together so closely as to almost occlude the nares, it is necessary to obtain a model of the pharynx, not in its relation of rest, but as it appears when closed, in order that the artificial palate made for the case may best meet the requirements of the case; this can only be done if the impression is taken with the mouth parts in a state of rest, while the pharyngeal portion is taken in the same impression during the act of swallowing. The recommended procedure is as follows:

The trial plate is extended posteriorly until it almost comes in contact with the posterior portion of the pharynx. The posterior edge of this extension is to receive a slight wall of *wax* to prevent the plaster, when the impression is taken, from passing into the throat. The wax is also added along the upper side of the extension to confine the plaster better to the upper surface. The plate may then be tried in the mouth to determine if the extension in any way interferes with

[1] "American Textbook of Prosthetic Dentistry."

the act of swallowing. If satisfactory, a thin mix of plaster is placed upon the extended portion of the plate, introduced into the mouth, placed in position, and the patient requested to swallow two or three times, and then remain as quiet as possible. When the plaster has hardened the impression is removed and placed in position upon the model. Dr. Ottolengui states [1] that when it appears evident from the activity of the throat muscles that this procedure will be necessary, it is best to secure this impression before correcting the model in regard to the borders of the cleft, as previously discussed. It is from such a model that Dr. Ottolengui makes his modified Kingsley velum, which resembles in its action the velum obturator of Dr. Case.

The Construction of an Artificial Velum.—In constructing an artificial velum a model of the two flaps of which the velum consists is made. The palatal flap is first formed, either of wax or sheet gutta percha. If the model is to be tried in the mouth, which is always the safer plan of procedure, especially with the inexperienced, it is best to utilize gutta percha; if not, the model may be formed of wax. A piece of gutta percha is formed to cover the cleft; this will assume a triangular form, as previously observed. When the piece for the palatal flap has been constructed as desired, it is warmed and pressed against the model, so that a desirable adaptation may be secured. When this has been accomplished and all the edges made thin, while in position upon the model, a blast of cold air should be directed against the gutta percha to harden it.

The second or upper flap is formed after the method indicated for the palatal flap, excepting that its pos-

[1] "American Textbook of Prosthetic Dentistry."

terior edge must be made to meet the ridge of the pharynx. The reason for this has been previously noted. When the second flap has been satisfactorily conformed to the model, while in position, and firmly held in place with one hand, the other hand is utilized to apply pressure at the center of the posterior part, to bend it upward to assume the desired form.

The two flaps are next placed in position upon the model and sustained in their proper relation with wax. The case may now be tried in the mouth, and when found to be satisfactory the formation of the metal molds may be proceeded with, in which the soft rubber of which the velum is to be formed may be vulcanized. The flask recommended for holding the metal molds is of two parts, one of which has a square opening at its center; into this portion of the flask is placed the model of the velum, so that the palatal flap rests over the opening. The flask having been oiled, plaster of paris is adapted about the model of the velum and to the remaining portion of the flask. When this has set the plaster is easily removed from the flask, trimmed down, varnished, returned to the flask with the gutta percha velum in position, and oiled. Plaster is now applied to the surface of the velum and the surrounding plaster, and the other half of the flask, having been previously oiled, is adjusted to position and pressed into place. When this has hardened it is separated, and the third mold may then be formed. This is accomplished by pouring plaster into the opening at the top of the flask, filling the remaining space within the flask. A molding in sand is next prepared for each piece of plaster, and a casting made in type metal.

It is claimed[1] that if the surfaces of the molds are

[1] "American Textbook of Prosthetic Dentistry."

soaped before packing the soft rubber, it prevents the rubber from adhering to the metal molds.

The rubber is packed in the usual manner. It is well to remove the excess of rubber, otherwise the opening of the flask is likely to be rendered quite difficult. The best results are obtained in the vulcanizing process [1] if sufficient charcoal is placed at the bottom of the vulcanizer to extend beyond the water also placed therein. This enables the vulcanizing process to go on in the steam generated when heat is applied.

"The thermometer which registers the heat should indicate 240° for two hours; 250° for one hour; 260° for one hour; and 270° for one hour."

In this manner the rubber is prevented from being overvulcanized, which, if allowed to take place, quickly results in destroying the flexibility of the velum, and may be detected when the piece is taken from the flask by the *burned* odor which it emits.

The Construction of an Obturator.—It has been previously indicated that an obturator is best suited for those cases in which both the hard and soft palate are involved in the cleft. The procedure is as follows: The model is obtained in the usual manner. The opening in the hard palate is closed with wax, and dies and counterdies prepared that a swaged plate may be prepared to fit the hard palate, and cover the existing opening in this region. The plate is attached usually to the first permanent molars, by means of clasps, and to safeguard the teeth from caries it is best to first cover them with shell gold crowns and then adapt the clasps.

When the plate and clasps have been desirably adapted, the next step in the procedure is to temporarily attach to the upper surface of the plate a device for sus-

[1] "American Textbook of Prosthetic Dentistry."

taining the impression material, that a suitable impression may be secured. Copper wire in the form of a loop may be used for this purpose, and temporarily attached to the plate with soft solder.[1] The impression material is softened, the wire loop embedded in it, and the plate and material introduced into the mouth. As only an approximation of the form of the cleft and tissues is desired at this time, the material may be quickly withdrawn, hardened, and trimmed down to more closely approximate the desired outlines. When this has been accomplished, the material is again softened, introduced into the mouth, and the patient instructed to swallow several times. In this manner the muscles so act upon the softened material that the form is secured which, reproduced in the finished piece, will enable the patient to completely close the opening into the nasal cavity when the instrument is in position. Usually it will be found necessary to trim the surfaces against which the muscles act in closing to "further reduce the size of the bulb, especially at the posterior end, where the ridge of the pharynx is expected to touch it."[2]

The case is completed in the following manner: "The model having been brought to this point, plaster is mixed as for an impression, and a little placed upon the upper side of the plate, extended from where the impression material ends sufficiently forward to reach the anterior end of the fissure when placed in the mouth. The plate, with plaster upon it, is then quickly carried into place, and upon removal the plaster will have taken an impression of the forward part of the cleft. It is cut away to a level with the upper side of the impression mate-

[1] "American Textbook of Prosthetic Dentistry."
[2] *Ibid.*

rial, and with it completes the model of the obturator, which must now be reproduced in hard rubber.

"Plaster molds are next made in which to reproduce the bulb in hard rubber, and when flasked and ready for packing the bulb is made as follows: Patterns of the upper and under surface are cut from thick tin foil, and a single pattern to extend around the sides and end. These are similarly cut from sheet rubber, and are united in the general form of the bulb by placing the edges together and pinching them fast with a pair of tweezers. Before finally closing, water should be introduced, filling the bulb about three-quarters full, great care being observed lest the edges of the rubber should become wet, which would prevent perfect union and allow an escape of steam during vulcanization, the result being a collapse of the bulb. If these steps are accurately taken and the flask tightly closed, the bulb will be thoroughly well filled out and will be a perfect reproduction of the model.

"The bulb is next to be fitted to the plate, the proper position being determined by models which were taken while the plate and wax (impression material) model were united. A hole is then drilled through the bulb and plate, through which an iridio-platinum bar is passed and soldered to the plate, the opposite end being screw-cut and supplied with a nut. The hole drilled through the bulb for the passage of the bar also serves for the removal of the water used in vulcanizing. The surface of the plate over which the bulb is to lie is smeared with gutta percha, the bulb slipped over the bar, and the nut turned down until it impinges. Then by warming the plate over a Bunsen burner the gutta percha is softened and the nut screwed down, driving the obturator tight against the plate, the gutta percha

serving to form a water-tight joint. The plate and bulb are then polished and are ready for the patient."[1]

Dr. Case's Velum Obturator.—Dr. Case describes his method as follows: "The model of the body of the palate is formed first, and then inserted in the mouth for trial. This can usually be accomplished with the hand alone, by passing it back of its proper position and then bringing it forward. It should be done quickly and easily, or contraction of the muscles will prevent its accomplishment.

"At this time the lateral nasal extensions of the model should be abridged to facilitate introduction. They can be added at the time of investment and still further extended, as can other parts, by scraping the metal casts.

"The surface of the pharyngeal wall in the contracted position of its muscles, which represents the surface that is ultimately to close around and press against the peripheral border of the artificial veil, is obtained with a loop of No. 22 soft copper wire, the free ends of which pass into tubes embedded in the upper surface of the model.

"The loop is drawn out and bent to about the proper size and shape, and the model then inserted in the mouth for correction. This is repeated, bending, enlarging, or contracting, etc., until the wire is seen to rest along surfaces that are best adapted to unite in their action with the artificial veil for the ultimate closure of the naso-pharyngeal opening.

"The posterior line of wire should rest just in front of or slightly above the greatest contracted extension of the superior pharyngeal muscle. The surrounding muscles can be made to contract by a slight titillation of the surface, and, what is of the greatest advantage,

[1] Dr. Ottolengui in "American Textbook of Prosthetic Dentistry."

the pharyngeal walls above and below the wire can be readily seen and studied in their action through the open loop.

"The action of the muscles alone, springing forward against the pliable wire loop, pressing it back into its sockets, or bending it to fit their surfaces, will frequently cause it to mark the desired peripheral outline of the artificial velum. As the loop turns forward to pass beneath the openings of the Eustachian tubes, the pharyngeal surfaces will often be found corrugated and thrown into irregular folds, so that in finding the smoother path across these ridges to prevent the escape of air at the border of the veil through the sulci, it may be found desirable to raise or lower the wire upon one side more than the other. Forward of this it soon comes in contact with the upper surfaces of the palatal muscles as it enters the posterior nares.

"After fitting the wire to mark the desired outlines of the veil, the roll of compound which is to form the model of the border of the veil may now be attached to the loop, following the outline of its peripheral surface, and finally adjusted to the mouth to correct imperfections."

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